East Engin. Library
OCT 21 1931

INSTRUMENTS
INDUSTRIAL — SCIENTIFIC
(Reg. U. S. Pat. Off.)
Devoted to Measurement and Control Problems
Vol. 4. No. 10 Pittsburgh, Pa. October, 1931

IN THIS ISSUE

Editorial Comment

A Corrosion Tester for Pressure Vessels — Cloyd M. Chapman

Elinvar for Instrument Hairsprings — George P. Luckey

Measurement of Air Flow — E. Ower

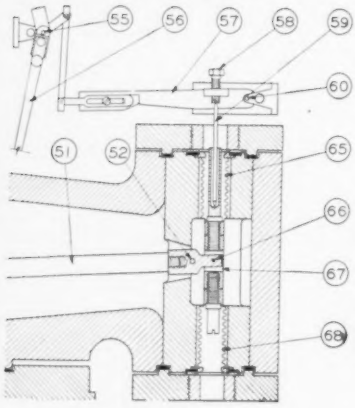
Speed and Acceleration — M. F. Béhar

New Instruments

- Photo-electric High Temperature Measurement and Control
- New Vacuum Thermocouple for Alternating-Current Reading
- Thermocouple Potentiometer
- New Flow Instruments
- Novel Automobile Timepiece
- Air Operated Recorder Controller
- New Federal Forest Products Laboratory Building
- Flush Type Graphic Instruments
- New Gage Protector
- New Temperature Regulator
- New Chlorine Comparators
- Tension Indicator
- Photo-Electric Relay Operates Shear for Cutting Hot Bars
- New Sheet Metal Tester
- Pulsation Dampener
- New Cathode-Ray Oscilloscope
- Non-Recording Time Controller
- New Float Operated Motor Starter
- New Type Contact Pyrometer
- Measurement of Velocity and Direction of Water Currents
- Space Heater Protects Control Apparatus

Place initials of interested persons in your organization opposite title and call it to their attention.

No Pressure-Tight Bearings in—



TAG Flow Instruments

TO transmit the flow movement from inside the manometer pressure chamber, which is at pipe line pressure, to the recording pen outside, which is under atmospheric pressure, without friction or leakage, is a problem to which has probably been given more attention in flow instrument design than any other.

The diagram above (in the center) shows the ingenious solution by which TAG design overcomes this stumbling block to accurate flow measurement and control.

The lever 51, which transmits the vertical movement of the float, engages yoke 67. This yoke is supported in position by two bellows, 65 and 68, one at each end. These bellows, being identical, are equally affected by pressure changes inside or outside the pressure chamber, and balance each other so that such pressure changes can cause no movement of the yoke. At the same time they allow the yoke to move without restriction up or down as the float falls or rises. The yoke extends through the inside of the upper bellows 65, enabling its motion to be communicated to the pen leverage system by pin 59.

Entire elimination of friction and the utter absence of any opening through the pressure chamber, which is sealed from the atmosphere, are exclusive TAG Flow Instrument features, making possible the full utilization of float movement in moving pen and removing every possibility of leakage.

Send for Catalog No. 1020-I, completely describing the: TAG Flow Recorder-Controllers for Liquids — TAG Flow Meters and TAG Orifice Meters for Gases — TAG Flow Recorder-Controllers for Gases — TAG Liquid Level Recorder-Controllers. Use the coupon below.

C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

Gentlemen: Please send me by return mail Catalog No. 1020-I describing TAG Flow Instruments.

Name.....

Address.....

C. J. TAGLIABUE MFG. CO.

PARK AND NOSTRAND AVE'S., BROOKLYN, N. Y.

Insist on Mercury Thermometers with the TAG-Hespe RED Reading Column

BRANCH OFFICES AND *FACTORIES

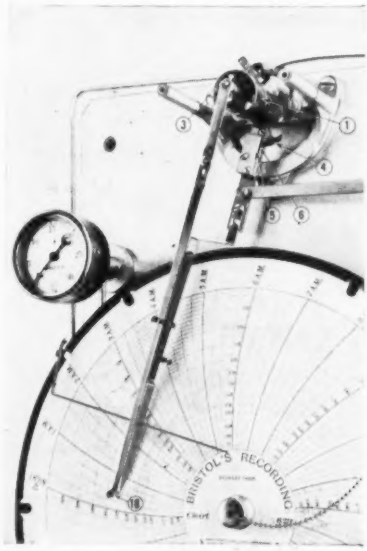
BIRMINGHAM, ALA. BOSTON, MASS. CHICAGO, ILL. *CLEVELAND, OHIO
PITTSBURGH, PA. PORTLAND, ORE. S. SAN FRANCISCO, CALIF.
*SHREVEPORT, LA. ST. LOUIS, MO. TORONTO, ONT., CAN.

TAG C. J. TAGLIABUE MFG. CO. BROOKLYN

BRISTOL Presents *to* Industry

a Full Floating Recorder Controller

Use of a *Free Vane*, floating between twin air jets, gives Temperature Control without distortion



A vane (4) is attached to the same shaft (3) as the recording pen arm (18). As the temperature to be controlled varies and actuates the sensitive helical measuring element (1), the shaft (3) turns and so causes the vane (4) to pass freely between the two opposing air jets (5) and (6). The discharge of the two nozzles is throttled and a back pressure is created which is utilized in effecting control without placing any restraint on the recording and controlling mechanisms.

EMPLOYING a unique and revolutionary principle of operation, this new BRISTOL *Free Vane* Recorder Controller marks an almost incredible advance in air-operated automatic control. It makes possible regulating the temperatures of industrial processes to a degree heretofore unobtainable.

Controller action is full floating. Under the influence of temperature fluctuations the ingenious *Free Vane* device utilized for effecting control actually floats from one position to another. It does no mechanical work. It experiences no resistance or friction. Nor does it interfere in any way with the motion of the recording element to which it is attached. Temperature indications are accurate. They disclose faithfully the state of the process under control. There is no distortion or restraint, either at, above, or below the control temperature.

The *Free Vane* Recorder Controller *gives precisely the control which the temperature record indicates.* It incorporates BRISTOL'S perfected sensitive actuating element of the popular helical tube type which has been so widely accepted by industry as the standard of accuracy.

A 24-page catalogue describing this remarkable new *Free Vane* Recorder Controller should be in the files of every executive. Just fill in the coupon and write for your copy.

THE BRISTOL COMPANY ~ WATERBURY ~ CONNECTICUT

Branch Offices: Akron, Birmingham, Boston, Chicago, Denver, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco

TRADE MARK
BRISTOL'S
REG. U. S. PAT. OFF.

INSTRUMENTS FOR INDICATING RECORDING CONTROLLING SINCE 1892

THE BRISTOL COMPANY I. 10-31
Waterbury, Connecticut
Please send catalog on BRISTOL'S Air-Operated *Free Vane* Recorder Controller to:

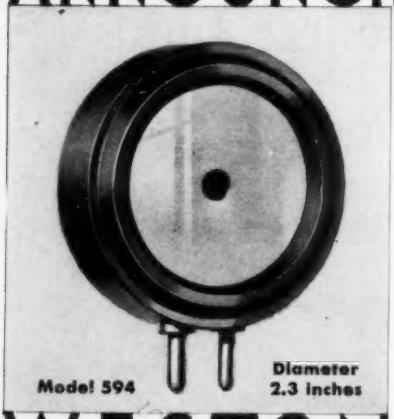
Name .....

Address .....

.....

When writing to the above company, please mention INSTRUMENTS

ANNOUNCING *THE NEW*



Model 594 Diameter 2.3 inches

WESTON PHOTRONIC CELL

[PHOTO-ELECTRIC]

Outstanding Features

Highly sensitive
High current output
(approx. 5 milliamperes in direct sunlight)
No drifting
No chemical change
No physical change
Unlimited life—as far as known
No deterioration on shelf

* * *

No dark current
No batteries
No polarizing voltage
No exciting voltage
No readjustments of the circuit
Non-microphonic
Withstands direct sunlight

* * *

No liquid
No glass bulb
No gas
No vacuum
Not easily damaged
Nothing to replace
Low cost

Dry type—amazing in performance — utterly simple in design—the new Weston Photronic Cell is radically different — a marked advance in light sensitive cells.

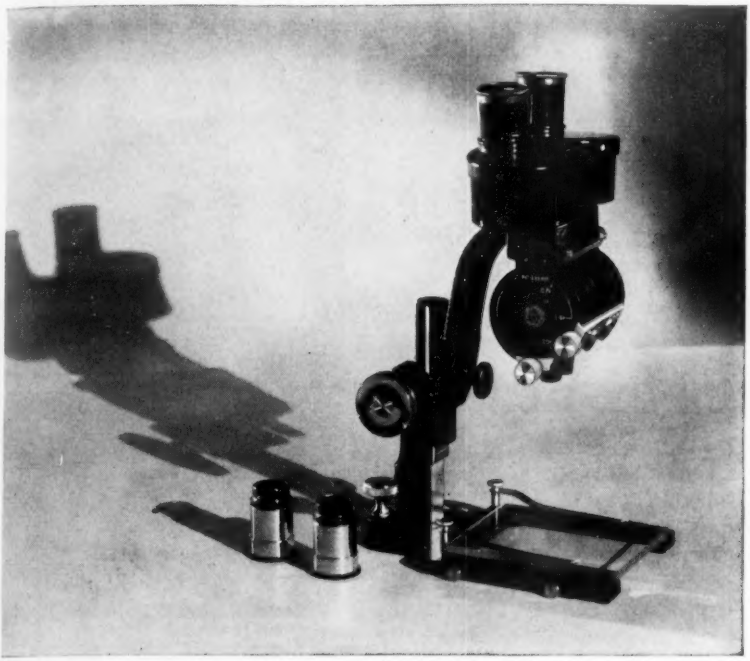
It is revolutionizing in operation. It establishes a new standard of performance. Almost limitless in application. And its cost is low.

WESTON

Circular YY, containing details, on request.

ELECTRICAL INSTRUMENT CORP.
591 FRELINGHUYSEN AVENUE
NEWARK . . . NEW JERSEY

When writing to the above company, please mention INSTRUMENTS



Quickly Interchangeable Magnifications

THE new model of the B & L Wide-Field, Binocular Microscope AKW-5 has an improved Drum Nosepiece. Former models of this instrument carried three pairs of matched objectives in the nosepiece, all of which were non-removable. The new Drum Nosepiece contains only one pair of objectives (the 0.7X) permanently mounted. The other two pairs can be readily removed by simply sliding out the objective mount. Other objectives, similarly mounted, can be quickly substituted, making available a much wider range of quickly interchangeable magnifications.

Write for a complete description of the instrument. BAUSCH & LOMB OPTICAL COMPANY, 615 St. Paul Street, Rochester, N. Y.

BAUSCH & LOMB

When writing to the above company, please mention INSTRUMENTS

Cold-headed Bolts

are HOMO normalized

LEADERS like the Oliver Iron & Steel Corp. of Pittsburgh have found that HOMO Furnaces are the one best way of heating bolts and rivets uniformly and economically. Using big batteries of Homos, they secure a normalizing which they regard as practically ideal.

In normalizing, these companies find that by far the best results are attained by heating to a certain quite definite temperature. If the heating stops only a bit short of this temperature, the strains within the bolt are not properly relieved, while if the temperature goes too high, the bolt is unnecessarily softened. As in all other metallurgical processes, there is a happy medium which each manufacturer must determine in advance for his own product. The Homo furnaces are a success in normalizing because they hit the predetermined correct temperature so precisely and unfailingly.

Write For Catalog 93-I

WESTINGHOUSE ELECTRIC HEAT

LEEDS & NORTHRUP COMPANY
4901 STENTON AVENUE PHILADELPHIA, PA.

LEEDS & NORTHRUP

F-252

When writing to the above company, please mention INSTRUMENTS

TABLE OF CONTENTS
OCTOBER, 1931

Editorial Comment 525

A Corrosion Tester for Pressure Vessels 527
Cloyd M. Chapman

Elinvar for Instrument Hairsprings 532
George P. Luckey

Measurement of Air Flow 533
E. Ower

Speed and Acceleration (Cont.) 541
M. F. Béhar

New Instruments

Photo-electric High Temperature Measurement and Control 557
New Vacuum Thermocouple for Alternating-Current Reading... 558
Thermocouple Potentiometer 559
New Flow Instruments 561
Novel Automobile Timepiece 562
Air Operated Recorder Controller 563
New Federal Forest Products Laboratory Building 564
Flush Type Graphic Instruments 565
New Gage Protector 567
New Temperature Regulator 567
New Chlorine Comparators 568
Tension Indicator 569
Photo-electric Relay Operates Shear for Cutting Hot Bars in Rolling Mill 570
New Sheet Metal Tester 571
Pulsation Dampener 572
New Cathode-Ray Oscilloscope 573
Non-Recording Time Controller 574
New Float Operated Motor Starter 574
New Type Contact Pyrometer 575
Measurement of Velocity and Direction of Water Currents 576
Space Heater Protects Control Apparatus 578

Catalogue Library 7-8
Buyers' Guide 10
Book Shelf 540, 555, 556
Advertisers' Index 17
Index Card Section 18

Richard Rimbach, Managing Editor **M. F. Béhar**, Engineering Editor

Published the 15th of each month by

INSTRUMENTS PUBLISHING COMPANY
3619 FORBES STREET, PITTSBURGH, PA.

Joseph J. Vigneau, President **Richard Rimbach**, Vice-Pres. & Treasurer

TERMS OF SUBSCRIPTION
Annual Subscription: $2.00; Single Copies, 25c.
Copyright, 1931, by Instruments Publishing Company

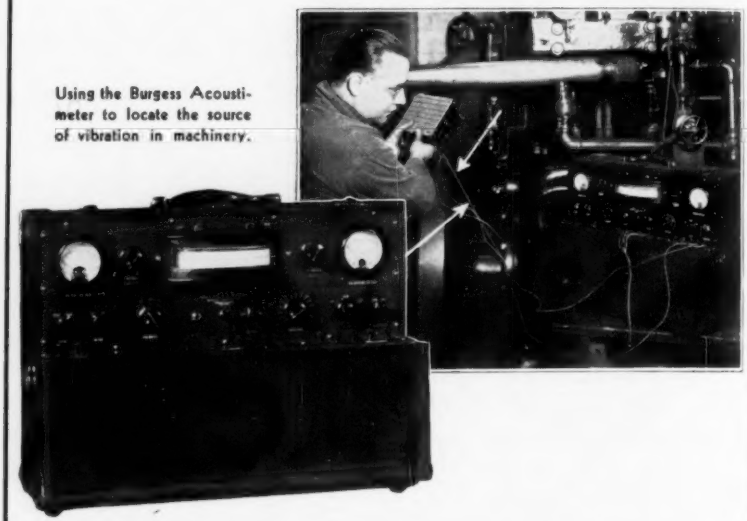
NOISE MEASUREMENTS

Made Scientifically

—Quickly and Accurately

with the

BURGESS ACOUSTIMETER



Using the Burgess Acoustimeter to locate the source of vibration in machinery.

THE Burgess Acoustimeter is a modern instrument designed to meet the ever increasing demand for a simple, accurate and scientific measurement of noise and vibrations. It has been successfully applied to the measurement of city noises, office noises, gear noises, machinery vibrations, detonation, architectural acoustics and similar commercial problems.

Write for Bulletin No. E9

BURGESS-PARR COMPANY
DIVISION OF C. F. BURGESS LABORATORIES INC.
111 WEST MONROE STREET
CHICAGO, ILLINOIS

When writing to the above company, please mention INSTRUMENTS

EDITORIAL COMMENT

"The Open Door"

LITTLE does it matter whether the "lag" of an electron tube is a millionth, a billionth or a trillionth of a second. It is such a vanishingly small interval that the most sensitive mechanical, electromagnetic and fluid relays seem extremely sluggish in comparison. No wonder, therefore, that many manufacturers of automatic control instruments have pounced eagerly upon this means of actuating the largest valves and dampers in quick and obedient response to the feeble impulses of sensitive primary elements. With the photoelectric forms of electron tubes, there is not even need of mechanical or electrical connection between the primary element and the operating mechanism: a beam of light does the trick.

Already, the number of successful automatic control applications is such that a mere list would cover several pages of fine types. All industries have begun to benefit, and some are thoroughly "sold" on electronic control. Temperature, pressure, speed, flow, light and other processing and working conditions are regulated with extreme accuracy. Especially light. Even that elusive physical property known as color is judged by electric eyes. And such results as counting articles traveling on a conveyor, sorting beans or buttons, or operating a drinking fountain as you bend over it, have become commonplace.

This newborn member of the family of devices employed in Instrumentation is an infant prodigy.

But let us, the servants of Instrumentation, not be carried away with excessive enthusiasm: Let us not take it for granted that the electrical industry has solved *all* of our problems. Let us not only thank the electronic engineers but emulate them . . . yes—and go them one better!

For serious problems remain to be solved before the electron tube, this lusty boy, reaches the full stature of a man in our own industry. His development has been marvelous but it has been one-sided. To put it in the parlance of Instrumentation, "you can get a wonderful on-and-off action with these gadgets but you can't get an exactly proportional amplification."

There, oh ye physicists in the research departments of instrument making and using companies, is a challenge to your ingenuity and resourcefulness! Instrumentation is measurement and control—measurement not only in the sense of "go" and "no go" but in its true sense of assigning exact numerical values. As long ago as 1924 we saw an electric eye sorting cigars into twenty-one grades of color, but the research man who explained it confessed that it was not likely to provide smaller intervals and that it was altogether incapable of providing a *continuous* scale. Since then, much progress has been made and a recent development is the actual measurement of high temperatures by amplifying the variations in the intensity of full radiation.

When writing to the above company, please mention INSTRUMENTS

Exact measurement requires not only that the instrument be sensitive but that its indications be accurate—that is to say that a continuous scale of values be made possible. Thanks to the electronic engineers we have a degree of sensitivity beyond our wildest dreams of only a few short years ago. It is up to us to utilize this miraculous sensitivity so that the *true* value of whatever is measured will be indicated and recorded on conveniently large dials and charts, and so that the setting point of an automatic controller can be raised or lowered on a numerical—not an arbitrary—scale.

These developments will come. And soon. But even at this stage we believe that the General Electric Company is perfectly right in declaring that the name Thyratron was applied to one of its series of tubes because it comes from a Greek word which means "door"—because electronic tubes are the *open door to marvelous developments.*

INSTRUMENTS EMPLOYMENT SERVICE

No charge for insertion of notices, which should be addressed to *Instruments* Employment Service, 3619 Forbes Street, Pittsburgh, Pa., should be written tersely and must be received by the 25th of the month. In replying, put identification number on *both* envelope and letter.

MEN AVAILABLE

INSTRUMENT MAKER: 3½ years experimental laboratory of lamp company; 2 years experimental laboratory of electrical company. J-2.

PYROMETER MAN: Graduate Pennsylvania State College. Had charge of pyrometer calibration laboratory in plant with 1100 pyrometers. J-3.

METALLURGIST: 1½ years University of Pennsylvania; 7 years night school Carnegie Institute of Technology. 2 years steel plant analyst; 7½ years plant metallurgist in foundry. Can read German, Polish, Bohemian and Russian. J-4.

METALLURGIST: Graduate University of Pittsburgh; 5 years steel plant metallurgist; 6 years sales metallurgist; 3 years metallurgist automotive plant. J-5.

ELECTRICAL ENGINEER: Graduate Charlottenburg Technische Hochschule; 8 years research engineer with chemical company; 4 years steel plant electrical engineer; can read German, French, Spanish and Italian. J-6.

INSTRUMENT SALESMAN: Mechanical Engineering Graduate; experienced sales and service most type of power plant instruments. District Sales Manager 5 years. Experience on gages, flow meter, CO_2 recorders, pyrometers and other testing equipment. J-8.

PYROMETER MAN: 8 years experience; expert electrician and gage (hydraulic, pressure, vacuum, etc.) service man; 3 years instrument laboratory; education equivalent two years of engineering college. J-9.

INSTRUMENT ENGINEER: Graduate Engineering College. Charge of instrument department in large industrial plant for 2½ years. J-10.

INSTRUMENT MAKER: Dip. Ing. Charlottenburg, 2 years German Instrument company building electrical and temperature instruments. 1 year patent research bureau in New York. J-11.

RADIO OPERATOR: Graduate Dodge Institute, 1917. Commercial license either broadcast or telegraph. J-12.

INSTRUMENT SALESMAN: Graduate ME, 4 years control instruments, 2 years power plant specialties, 4 years manufacturing experience, in shop. Now N. Y. District Mgr. large rolling mill. J-13

PHYSICIST: Ph.D. 1927. Experienced in electric and magnetic measurements, testing and research. J-14.

PRECISION INSTRUMENT MAKER: 28 years experience on scientific and geophysical instruments. J-15.

temperatures by amplifying the variations in the intensity of full radiation.

A Corrosion Tester for Pressure Vessels

*Cloyd M. Chapman**

EXCEPT in the laboratory, there has been available almost no equipment suitable for corrosion testing. That which has been used in service tests has in each case been conceived by the individual user and been almost entirely home made. There are, of course, cases in which certain peculiar conditions demand special treatment. On the other hand, suitably designed standard equipment or apparatus should find a large field of usefulness.

Conducting service corrosion tests in pressure vessels is especially troublesome and inconvenient. Unless one is provided with apparatus suitably designed for that purpose, the vessel under test must be shut off from pressure, sometimes drained of its contents, and opened and closed, often laboriously, each time it is desired to insert, remove or inspect the test specimens.

A corrosion tester has been developed which provides a simple and convenient means of exposing test specimens to the fluids, either gases or liquids, in existing pressure vessels while working under pressure and other normal operating conditions. It offers easy means for making a variety of tests, such as:

1. Determination of the relative ability of various metals to resist corrosion when subjected to a given fluid, as for instance, materials for pipe lines, condenser, heater or exchanger tubes, or any part of a pressure vessel subjected to the fluid in question.

2. Determination of the relative tendency of various fluids under given conditions to corrode a particular metal as for instance, in the test of a material for heat exchanger or condenser tubes subject to the action of two fluids, at the same time.

3. Detection of changes taking place in the fluids carried in a system, e.g., before and after deaerating equipment, as a check on its effectiveness.

4. Ascertaining the rate of deposition of scale or the character of scale being deposited.

The corrosion tester is clearly shown in Figs. 1 and 2. A yoke and stuffing box assembly forms a guide and means for projecting a spindle through a valve and connection into the desired point of application. Test specimens are carried on the end of the spindle. Inspection of the specimens may be made as often as desired by removing the yoke assembly from the valve, which remains permanently in place as long as tests are to be made at that point. This makes it possible to carry on tests without interrupting pressure or other normal operating conditions in the vessel.

The yoke is a special heat-treated aluminum alloy solidly fixed to the stuffing box. The stuffing box is turned from solid brass bar stock, and provided with ample packing space. It is fitted with a turned brass follower and a turned duralumin follower cap with a hexagon head of standard wrench size. The box is packed with square section graphite ring packing.

The spindle is of stainless steel and has double lead threads which work in a bronze bushing firmly fixed in the top of the aluminum yoke. The specimens are attached to the end of the spindle by means of a hexagon head stainless steel tap bolt. A large handwheel and the double lead threads facilitate easy and quick movement of the spindle.

*Consulting Engineer, New York, N. Y.

cal instruments. J-15.

A special heavy wall stainless steel double ended nipple with hexagonal wrench-head provides the connection between the valve and pressure vessel to be used for the tests. The valve is of standard gate construction, except that one end is specially faced and provided with a straight thread to fit that on the base of the stuffing box, which holds a suitable gasket. The joint is made tight by means of a ring type asbestos filled copper gasket or other suitable style. The hexagonal base on the stuffing box permits the use of a wrench to make up this joint.

The tester has been designed for use on pressures up to 400 lbs. A 200-lb. all brass valve is suitable for pressures up to that amount, and a 400-lb. monel valve for the higher pressures. Valves of other materials and for other intermediate pressures may be used if they are available in suitable style. All other parts of the tester are standard and interchangeable for use with either valve.

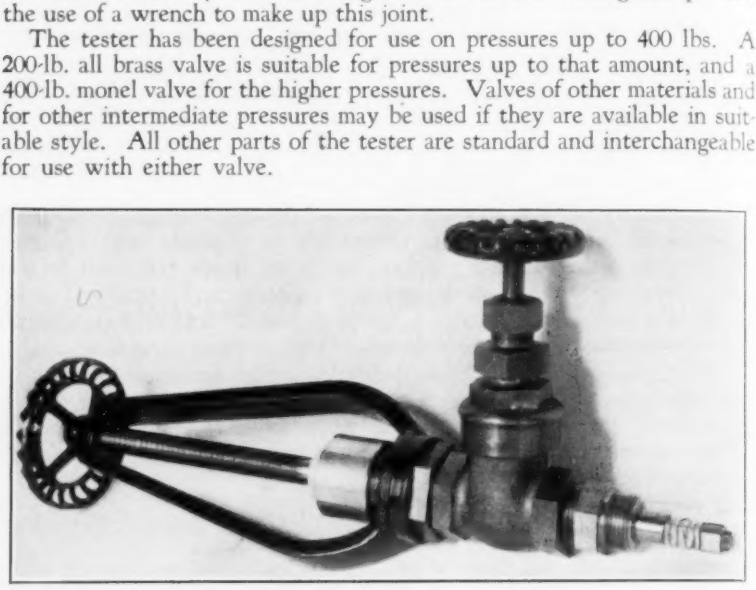


Fig. 1

After the connecting nipple and valve are once installed, it is not necessary again to interrupt the normal operation in the test vessel. With the spindle fully withdrawn and the test specimens attached, the assembly is screwed to the valve, the valve opened and the specimens projected into the vessel.

Two special types of specimens are suggested for use with the tester: (1) a very fine wire of the metal to be used in test wrapped on a special notched porcelain spool; and (2) a small cube of the metal to be tested.

Wire test specimens will be found of particular advantage for quickly testing the relative corrosiveness of fluids or the relative resistance of various materials to corrosion in a particular fluid in industries where weighing, microscopic, or photomicrographic apparatus is not available. It provides for a test, among others, based entirely upon visual examination.

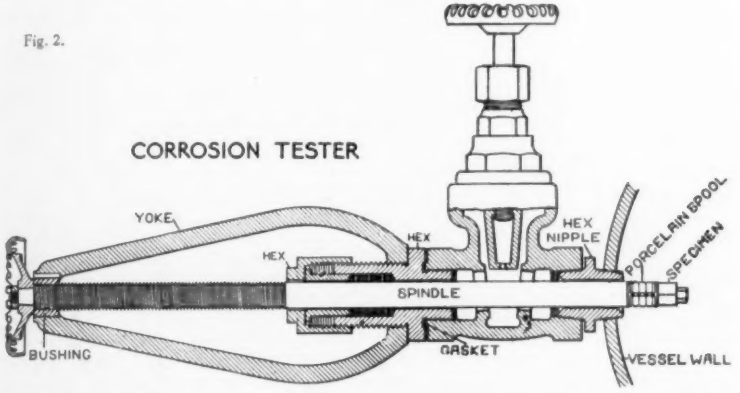
The porcelain spool, referred to above, is of rectangular shape with a hole for the supporting bolt and with four notches on each of the four longitudinal edges. It weighs about 3½ grams. Figs. 1 and 2 show the spool, with wire specimen, attached to the spindle.

To prepare the samples, a single strand of wire should be wound once around the spool. The four sets of notches provide sufficient space on the spool to wind four wires separately from each other, so that wires of

varying sizes or of different grades of metals may be tested at one time. The standard brass and monel valves referred to above provide sufficient clearance space back of the gate to use two spools at one time, which provides for eight wires.

After the specimens have been assembled, the tester is put into service. At the end of pre-determined periods the specimens should be momentarily removed and the wires inspected for progress of corrosion, noting whether all of the strands are intact. The relative resistance to corrosion of the wires of various metals, for instance, will be indicated by the relative order in which these wires break due to the disintegrating action of the corroding medium. Likewise the period of time required for the medium to corrode each wire specimen to the point of breakage is a measure of the rate of corrosion, indicating that corrosion has proceeded in that period to a depth equivalent to half the diameter of the wire.

Fig. 2.



The exposure periods will be governed by the materials and sizes of the specimen wires, and by any available prior knowledge of the corrosiveness of the medium. Some preliminary tests may be neceessary to determine the proper exposure periods. Specimen wires, having a very small diameter, —only a few thousandths of an inch,—are preferable, as the smaller the wire the less time will be required for exposure. Wires of some of the more common metals as Bessemer steel, pure iron and others, and also of certain alloys, are readily available in sizes down to .003″. The convenience of operating the tester, the short time required for making these tests using very fine wires, and the inexpensiveness of specimens and their preparation are attractive features of the method.

The second method of test suggested for use with the tester requires a test specimen preferably in the shape of a ½″ cube having one or more of its surfaces polished. The exact shape and size of specimens may be varied if desired. It is important, however, that the greatest dimension across the specimen be no greater than the diameter of the spindle of the tester, so that it will pass through the valve and connection. Three ½″ specimens may be tested at one exposure, or a greater number if they are sufficiently smaller. Specimens may be insulated from one another and from the tester, if desired, by the use of non-metallic bushings and washers The surface is not polished to such a high degree as to tend to cause general inhibition of corrosion, but is sufficiently smooth to be satisfactory for the purposes of the test.

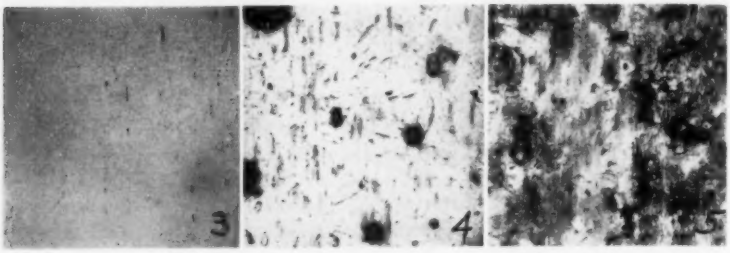


Fig. 3. Prepared specimen Bessemer steel before subjecting to test.
Fig. 4. Bessemer steel exposed to freshly boiled distilled water containing 1.89 g. per gal. CO_2.
Fig. 5. Bessemer steel exposed to distilled water containing 0.61 g. per gal. O_2 and 0.12 g. per gal. CO_2.

After the specimen has been subjected to test, it may be examined with a microscope or the results recorded by means of photo-micrographs. The polished surfaces of the specimen offer a means of readily detecting with a microscope the nature and extent of the corrosion which has taken place in a very few hours. A microscope giving magnifications of about 40 or 50 diameters will be found very satisfactory for this purpose. The pencil pocket type which is available on the market will be found very handy.

That the test is very delicate is indicated by the fact that a very few hours exposure may be sufficient to indicate the difference in amount of corrosion produced by very small differences in the quantity of corrosive elements. Attention is called to the exhibit of photomicrographs of Bessemer steel specimens tested in the laboratory. All are at magnifications of 50 diameters. Fig. 3 shows a prepared specimen before subjecting to test. Figs. 4 and 5 are of polished specimens after total separate immersion in various waters for 20 hours at room temperature. Fig. 4 represents a specimen exposed to freshly boiled distilled water to which has been added 1.89 grains per gallon of CO_2. A light tarnish and etch show over the entire surface with spots of localized corrosion. In Fig. 5 is shown a typical portion of a specimen exposed in a distilled water containing 0.61 grs. per gallon of o_2 and 0.12 grs. per gallon of CO_2.

Results which have been obtained with use of this method both in the laboratory and in service tests have proven remarkably concordant.

In making a determination, for example, of the ability of different metals to resist corrosive action of a fluid, the comparative results of the character and extent of corrosion on several series of specimens, all subjected for an equal period of time and under similar conditions, offer a quick indication of their respective values. Several specimens of each metal may be tested to obtain an average result.

In Figs. 6 to 9 and 10 to 13 are shown the results of two separate tests, in each case with four metals (Bessemer steel, charcoal iron, copper-bearing wrought iron and hand-puddled wrought iron), in water from the Schuylkill River. The tests were made two months apart under exactly similar conditions and for 20 hours duration.The photomicrographs are all at magnifications of 50 diameters and are typical of the entire polished surface of each respective specimen. It will be noted that in each test the Bessemer steel specimen showed the most severe corrosion. Charcoal iron appears a little more resistant though not so effectively as copper-bearing wrought iron. Hand-puddled wrought iron was in both cases almost entirely free of corrosion. These tests indicate the ability, mentioned above, to distinguish by this method between different metals for resistance to corrosion, and also offer evidence of reproducibility.

Some operators may prefer to use other methods of test. The tester is adapted to other methods and can accommodate other forms of specimens. For instance, a fine wire specimen having relative light weight compared to the surface area exposed is especially adapted to tests by the loss of weight per unit area of surface method. Likewise a number of specimens cut from thin sheet metal may be used with proper insulating arrangements in tests by the loss of weight methods.

As has been pointed out the tester may be utilized for various test purposes, various methods of test and with various types of specimens. In these important respects it has a broad field of usefulness.

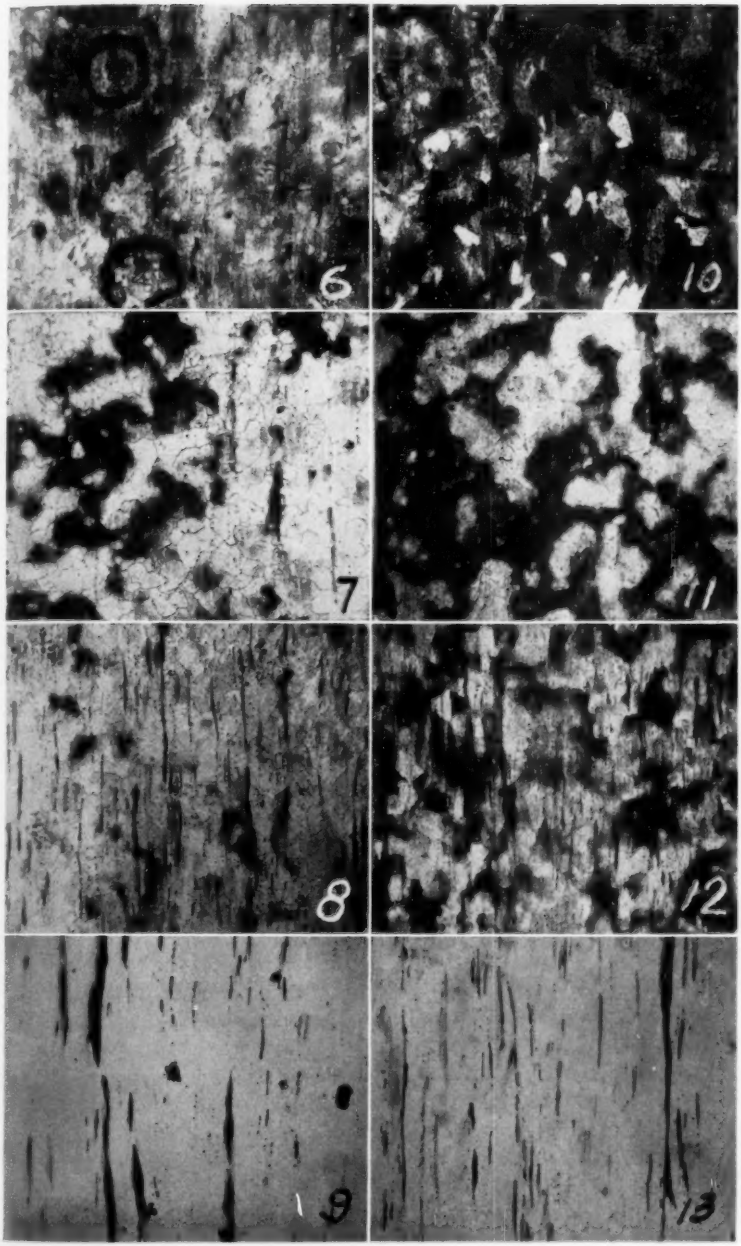


Fig. 6. Bessemer steel. First test in Schuylkill River water.
Fig. 7. Charcoal Iron. First test in Schuylkill River water.
Fig. 8. Copper-bearing wrought iron. First test in Schuylkill River water.
Fig. 9. Hand-puddled wrought iron. First test in Schuylkill River water.
Fig. 10. Bessemer steel. Second test in Schuylkill River water.
Fig. 11. Charcoal Iron. Second test in Schuylkill River water.
Fig. 12. Copper-bearing wrought iron. Second test in Schuylkill River water
Fig. 13. Hand puddled wrought iron. Second test in Schuylkill River water.

Elinvar for Instrument Hairsprings

*George P. Luckey**

ELINVAR, a nickel steel alloy invented and improved by Dr. Ch. Ed. Guillaume, Director, of the International Bureau for Weights and Measures, has now been developed to a point where it offers remarkable possibilities in instrument construction.

The elasticity of Elinvar is unaffected by temperature changes. Elinvar is not strongly affected by a magnetic field and cannot be permanently magnetized. It will not rust. These qualities make Elinvar very desirable for use in hairsprings.

During the past few years the Hamilton Watch Company and Illinois Watch Company have been experimenting with Elinvar hairsprings and have produced railroad grade watches of remarkable properties. They are relatively unaffected by magnetic fields, they are free from the errors in timekeeping due to rusty hairsprings and they eliminate troubles attendant upon the conventional method of obtaining proper timekeeping qualities with variations in temperature.

A split-rim bimetallic balance wheel is used in high grade watches to overcome the change in elasticity of the steel hairspring with change in temperature. This balance wheel, which is very difficult to manufacture so that it will be dynamically stable, offers numerous difficulties. But if the hairspring is Elinvar, a balance wheel with a solid-rim can be used to replace the conventional split-rim balance and equal or better compensating qualities can be obtained. This balance wheel can be made of non-ferrous metal. The combination of an Elinvar hairspring with a solid-rim monometallic balance wheel is practically unaffected by magnetism that may be experienced in a watch due to the permanent magnetization of its steel parts. If the standard watch is placed in a very strong magnetic field, it will stop and refuse to function after being removed from this field. A watch equipped with an Elinvar hairspring and a monometallic balance will show only a very slight variation in time after all of the steel parts have been permanently magnetized to the highest degree.

*Director of Research, Hamilton Watch Company.

American Askania Corporation announces the change of address from 622 Marine Bank Building to 809 Merchants & Manufacturers Building, Houston, Texas.

Announcement has come from the general offices of the International-Stacey Corporation, Columbus, Ohio, that Mr. B. T. Ehrman, who was formerly located in the Chicago office of the International-Stacey Corporation, has been transferred to St. Louis as Division Manager, with offices at Room 2192 Railway Exchange Building.

Mr. Ehrman has been associated for a number of years with the Roots-Connersville-Wilbraham Division of this company in the sale of gas pumps, meters, blowers and other equipment. With the opening of the St. Louis office, he will also have charge of the sale of Ideco Oil and Gas Drilling and Pumping equipment, Stacey Brothers Telescopic, "Bullet" Pressure and Stacey-Klonne Dry Seal Gas Holders, Ideco Standard Steel Buildings, Ideco Airport and Airway equipment and Ideco Electrical equipment, in addition to the Roots-Connersville-Wilbraham line of products.

Fig. 13. Hand puddled wrought iron. Second test in Schuylkill River water.

Measurement of Air Flow

E. Ower, B.Sc. (Lond.), Hons.I., A.C.G.I.
Bramwell Medallist; Member of the Institution of Heating and Ventilating Engineers; Assistant in the Aerodynamics Department, National Physical Laboratory

CHAPTER IX.

MANOMETERS

We have already had occasion to note that the velocity heads which have to be measured in practice are usually not large: for example, the velocity head, under ordinary atmospheric conditions of temperature and pressure, does not reach 1 inch of water until the air speed is roughly 66 feet per second. Further, since the head is proportional to the square of the speed, it falls off rapidly at the lower speeds, it is, in fact, less than 0·1 inch of water at 20 feet per second, a speed by no means outside the ordinary working range. It follows that in order to determine low air speeds with sufficient accuracy by means of Pitot and static observations, sensitive manometers, capable of reading pressures of the order of 0·001 inch of water, or even less, will often be necessary.

Numerous and varied devices have been designed to supply this need. A number of these are, for different reasons, unsuitable for industrial use, and it is not proposed in this chapter to attempt a description of all the types of manometers that have been constructed or suggested. We shall confine our attention only to one or two types of different degrees of sensitivity, which have been proved by experience to be suitable for engineering practice, as distinct from laboratory conditions. The main difficulty in designing such manometers is experienced in combining high precision with the portability, robustness, and ease and rapidity of manipulation which are essential for their successful application to general practical use.

Editor's Note: Ower's "Measurement of Air Flow" can be obtained in book form from the Instruments Book Shelf at $5.00 post paid.

The Tilting Micromanometer.—This instrument is capable of giving all the accuracy that will be required save in exceptional circumstances. It is, in principle, a sensitive U-tube water gauge in which provision is made for microscopic observation of the water level in one of the vertical limbs. The U-tube is shaped as shown in Fig. 51; it consists of a long horizontal glass tube A, communicating at either end with the glass vessels BB, whose axes should be parallel and approximately vertical in the zero position. Each vessel is provided with a removable glass cap, ground in to fit, to which rubber tubes leading to the static and Pitot heads may be attached. Short vertical glass tubes with sealed ends project from the base of each cup and fit into corks, which in turn fit firmly

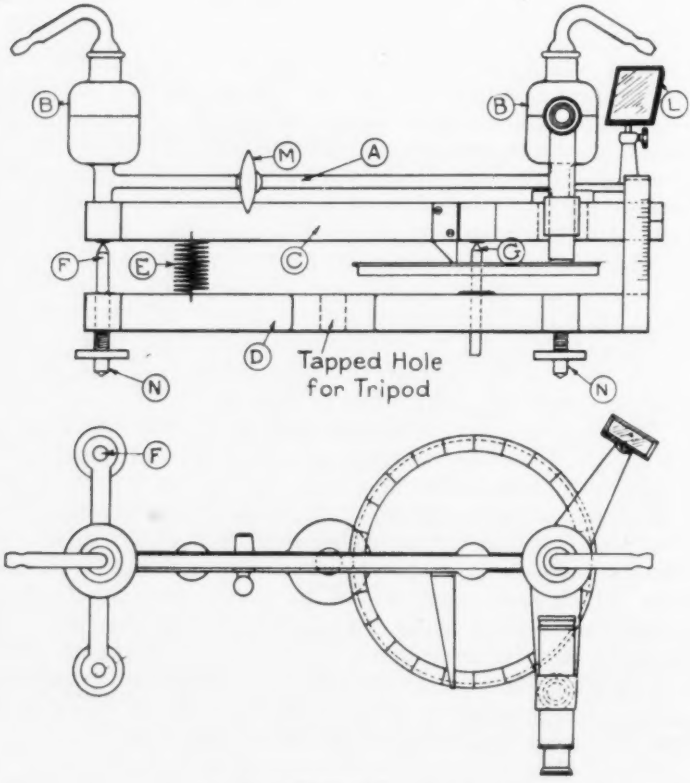


FIG. 51.—Tilting micromanometer.

in holes in the upper movable steel frame C. The latter rests, by means of a three-point support, on the lower fixed frame D, and is held firmly thereon by the spring E. The three-point support is arranged with two points FF under the left-hand vessel, the line joining these points being perpendicular to the axis of the tube A. These two supports are fixed, and the upper frame, with the U-tube, is tilted about the line joining them by means of the third supporting point G, which is formed by the hardened end of a vertical micrometer screw working in the lower frame. Of the two left-hand points, one engages a conical cup on the upper frame and the other a V-groove with its length horizontal and perpendicular to the axis of the tube A; the end of the micrometer screw bears against a small flat surface on the upper frame. In this way the tilting frame is given definite location without constraint. All the points and their seatings are of hardened steel. The position of the movable frame with respect to the fixed frame is observed by means of two indicating marks on the former, of which one moves over the graduated micrometer wheel and records fractions of a turn of the screw, and the other indicates complete turns on the fixed vertical scale on the lower frame. A microscope K, with cross-wires in the eyepiece, is carried by the upper frame for observing the level of the liquid in the right-hand vessel, and it is advisable for facilitating observation to have also a small adjustable mirror L, by means of which light from any convenient source can be reflected through the glass vessel into the microscope. The field of vision is then brighter above the water level than below, and the line of demarcation can be sharply focussed. A tap M should be provided to prevent spilling of the water whilst the manometer is being moved from place to place.

The instrument is often best used when mounted on a tripod. For this purpose it is desirable to provide the lower frame with a screwed hole to take a tripod such as that ordinarily used for Dumpy levels or theodolites. It is as well to have also three levelling screws NN on the lower frame to adjust the zero of the instrument if it should be found more convenient to rest it on a bench or table. A further convenient practical step is to bore eccentric holes to take the two cup supports in the two corks fitting into the holes provided in the tilting frame. In this manner some adjustment is provided for small variations from the standard dimensions in the glassware, since it is not possible to make this exactly to size in every case.

In using the manometer, the tubes from the Pitot and static heads should be connected to the cups before the zero reading

is taken, as the instrument may easily be displaced whilst the tubes are being fitted. It may be noted here that the caps fitting into the necks of the cups should be greased with a small quantity of vaseline over the region of contact in order to ensure the absence of leaks at the joints. The glass tube A should initially be approximately horizontal, and the zero reading is obtained by observing the readings on the fixed scale and the micrometer wheel when the cross wires of the microscope intersect the image of the water level. The total head and static tubes are then inserted in the pipe in which the air speed is being measured, and the movable frame is tilted by means of the screw until the image of the water level again coincides with the intersection of the cross wires.

Let d be the difference between the initial and final readings, expressed in turns and fractions of a turn of the wheel;

l_1 be the distance between the cup centres in inches;

l_2 be the perpendicular distance of the axis of the micrometer screw from the line joining the two fixed points;

t be the pitch of the micrometer screw in inches;

and p be the pressure difference in inches of water.

Then, if the angle of tilt be not too great,

$$p = td\frac{l_1}{l_2}. \quad . \quad . \quad . \quad . \quad (1)$$

Convenient practical values of l_1, l_2, and t are 13 inches, 10 inches, and 0·05 inch respectively. The available travel of the micrometer screw should not exceed 20 turns, giving the instrument a range of about $1\frac{1}{4}$ inches of water, and the diameter of the screw over the thread should be at least $\frac{3}{8}$ inch. Smaller sizes lead to " sloppiness " as the thread wears.

If a higher range is required, it should not be obtained by increasing the length of the screw, since the large angles of tilt which this course entails at the higher end of the range introduce errors for which it is necessary to make due allowance, and the above equation is no longer valid. It is preferable to increase the distance between the cup centres; a 26-inch U-tube used in place of a 13-inch tube would have double the range, and such a tube could quite conveniently be mounted on a frame designed for a 13-inch tube. It will be found, however, in practice, that when the velocity head exceeds that covered by the range of a 13-inch tilting manometer, the use of an ordinary U-tube water gauge will probably give sufficient accuracy in most cases.

An important consideration in connection with the tilting manometer is that it is an absolute standard which does not require calibration against another manometer. Of the dimensions which determine the reading for a given applied pressure difference, two, viz. the pitch of the screw thread and the distance of its axis from the line joining the fixed points, can be made to size sufficiently closely to limit errors in the readings to less than 0·1 per cent. The third important dimension, that is, the distance between the cup centres, cannot be made to a given size with such precision, but can be measured by calipering to 0·01 inch without difficulty. With careful workmanship the overall accuracy of the instrument should be within 0·1 per cent. over the entire range.

If this degree of accuracy is required at the higher pressures, a small correction must be applied to the readings in this part of the range. In equation (1) the product td represents the height h in inches through which the micrometer screw moves, that is the vertical distance by which one point on the movable frame is raised or lowered above another point, which does not move vertically. The assumption underlying equation (1) is that the length of the line joining these points is constant and equal to l_2, the distance between the axis of the micrometer screw and the fixed axis of rotation of the tilting frame. Actually, of course, the length of this line on the moving frame, i.e. the "leverage," is not constant, and only has its value assumed in equation (1) in the initial position. As the micrometer screw moves, its point slides along the hardened steel surface on the moving frame with which it is in contact, so that the leverage changes. It is easy to show that the true leverage for the reading d in equation (1) is $\sqrt{l_2^2 + t^2d^2}$ instead of l_2 as is therein assumed, so that the true pressure difference is obtained from the equation,

$$p = td\frac{l_1}{\sqrt{l_2^2 + t^2d^2}}. \quad . \quad . \quad . \quad (2)$$

The error incurred by using (1) instead of (2) is only 1 per cent. when $td = 1{\cdot}4$ inch, and decreases as td becomes smaller relatively to l_2.

The necessity for applying this correction can be entirely avoided if the upper end of the micrometer screw terminates in a horizontal, hardened, flat surface instead of in a point, and a hardened steel ball, fixed to the moving frame and resting on the flat end of the micrometer screw, is substituted for the plane bearing surface. The leverage will then be constant and

FIG. 52.—Glass-work for 26-inch Chattock manometer.

equal to l_2, the distance between the line joining the two fixed left-hand points (FF in Fig. 51) and the centre of the steel ball. The latter will now simply slide on the fixed end of the micrometer screw.

With a microscope having a magnification of 20 or 30 diameters the tilting manometer as described will be sensitive to pressures of less than 0·001 inch of water, which means that when this instrument is used with an ordinary Pitot-static tube a wind speed of 10 feet per second can be observed with an accuracy of about 2 per cent. By a modification of the glass-work the sensitivity can be greatly increased, unfortunately, however, at the expense of ease of manipulation and rapidity of working. The alteration consists in cutting the horizontal limb of the U-tube and connecting the two parts to a central vessel, one part being connected to the outside of this vessel near its lower end and the other being bent vertically upwards and passing up into the centre of the vessel. The modified arrangement can be seen from Fig. 52 which illustrates the glass-work of a manometer constructed on these lines, and from Fig. 53 which shows a complete instrument. It will be seen that the metal frame is of the type previously described.

This design of glass-work was first suggested by Chattock.* The vertical tube in the central vessel extends upwards for some distance as shown and is cut off square and ground. Distilled water is poured into the lower parts of the two cups and the central vessel, and into the upper portion of the latter, completely filling it, is admitted a quantity of medicated paraffin (" Nujol "), by the aid of the filling reservoir and tap shown in the diagrams. The paraffin does not mix with water, and

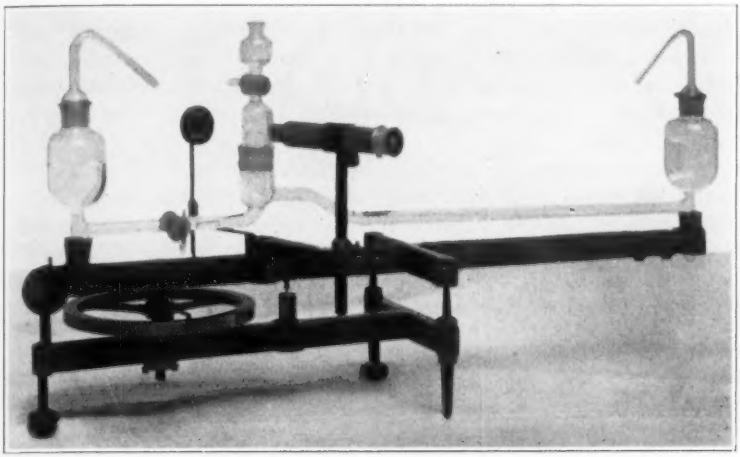


FIG. 53.—Chattock manometer (26-inch cup centres).

two well-marked surfaces of separation are formed, one outside the vertical tube in the interior of the central vessel and one within this tube. The liquid levels are adjusted, by regulating the quantities admitted, so that one surface of separation is formed on the open end of the central vertical tube, and has the appearance of a bubble resting on the mouth of the tube. If now a pressure difference is applied to the two end cups this bubble tends to become larger or smaller and its movement, which can be followed by suitable illumination from behind and microscopic observation, is arrested by giving an appropriate tilt to the frame by means of the micrometer screw.

Instruments of this type, having cups whose centres are 13 inches apart, are sensitive to pressure differences of the order of 0·0001 inch of water, the increased sensitivity being attributable to the fact that the motion of the liquid is observed in a narrow tube instead of in the relatively wide end cups.

* *Phil. Mag.*, 1901, p. 83.

Subject to neglect of surface tension effects, the motion of the bubble for a given pressure difference will be greater than the motion of the surface in one of the end cups in the ratio, approximately, of the area of the water surface in the cup to the internal area of the central tube. With a microscope of given magnification, therefore, the sensitivity of a Chattock type of manometer will be greater in this ratio than that of an ordinary tilting manometer. Actually, surface tension effects are by no means negligible, and reduce the sensitivity considerably. Nevertheless, as will be seen from a comparison of the figures quoted, this instrument is considerably more sensitive than the plain tilting manometer. Its chief disadvantage from an engineering standpoint is that, particularly with fluctuating pressures, the surface of separation is easily broken, in which case measurements have to be interrupted whilst a fresh zero setting is taken. Further, small zero changes may also occur as the temperature alters, on account of the different coefficients of thermal expansion of the water and the paraffin. A modification to eliminate this zero creep has recently been introduced by W. J. Duncan,* and for further details of the Chattock gauge the reader is referred to this paper and an earlier one which appeared in *Engineering* in 1913.†

* *Journal of Scientific Instruments*, vol. iv., 1927, p. 376.

† "The Chattock Tilting Manometer," J. R. Pannell, *Engineering*, 12th Sept., 1913, p. 343.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

WAVELENGTH TABLES FOR SPECTRUM ANALYSIS. Compiled by *F. T. Twyman & D. M. Smith.* Published by Adam Hilger, Ltd., London, 1931, second edition. Cloth, 5½x8½ inches, 180 pages. Price 14s.6d.

Various useful tables for use in chemical and metallurgical spectrography have been published since the first edition of this book was compiled, and the present time is opportune for the appearance of an up to date laboratory handbook containing all the necessary data for use in analysis by flame, arc and spark methods.

The most recent interferometric measurements of standard wavelengths have been included, and the tables of persistent lines have been revised to the I. A. scale. Tables of such lines for arc spectra (by J. W. Ryde and H. G. Jenkins), and flame spectra (by Prof. Lundegardh) are now reproduced with explanatory notes.

For those wishing to study the subject more fully from the standpoint of modern physics the section on "The Various Types of Spectrum" (by Prof. Andrade) and the complete table of ultimate lines by Dr. A. T. Williams (to which have been added spectroscopic information such as excitation potentials and temperature classification) will be of interest.

The Appendix deals with the phenomena of the condensed spark discharge and the precautions necessary for it t andardization for quantitative analysis.

THE HANDBOOK OF INDUSTRIAL INSTRUMENTS

M. F. Béhar*

CHAPTER XV

Speed and Acceleration

(*Continued*)

2. Installations, etc.

(d) Tachometer Drives

(*Addendum—Section 2 appeared in July number*)

Standardized Fittings for Tachometer Shaft Drives.

Thanks especially to the automotive industry, the development of flexible shafting for tachometers has reached at last the point where users can place entire reliance on its durability. There are several grades, however, but the difference in cost is so comparatively slight that none but the best should be used to drive industrial tachometers. Today, high-grade flexible shafting can be expected to outlive a tachometer. This being so, there would seem to be no necessity for going into details of construction of the various types of flexible shafting, beyond mentioning the new ball-bearing type in which the flexible core, constructed of 17 strands of music wire wound and counterwound in compact form, is suspended in ball bearings to minimize friction, insure steadiness of pointer indications on non-fluctuating speed applications and prevent all chances of disconnection from the instrument. The only important precaution that has to be observed with regard to installing the flexible shafting itself is to avoid very sharp bends anywhere and to avoid even moderately sharp bends within a few inches of either terminal.

Apart from the selection and installation of the shafting itself, however, most applications present some installation problems for the solution of which there have been developed various modernized and standardized fittings. These should be used in preference to those home-made contrivances often devised for lack of knowledge of the availability of fittings to meet all requirements. Most readers know that an automotive speedometer and drive assembly, for example, which gave satisfactory service on one vehicle is liable to go wrong when removed and inexpertly installed on another. Some industrial tachometers fail to render good service for no other reason than neglect of those important "trifles," the drive fittings. A few standardized fittings (Barbour-Stockwell Co. Instrument Dept.) are shown on page 542. The term "fittings" is here used to denote all such devices but in the trade it is applied to the standardized cable terminal and engine connections such as S. A. E., Reliance, or U. S. A. C. S. Fig. 560 shows one flexible shaft coupling of the straight type. Such couplings are made up with various standard ends. Fig. 561 shows a straight type single

*Engineering Editor

Fig. 560

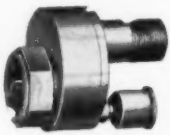


Fig. 561

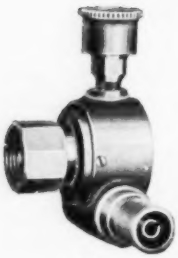


Fig. 562

Fig. 563

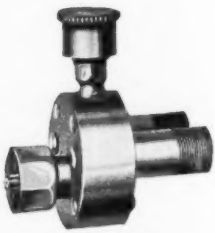


Fig. 564

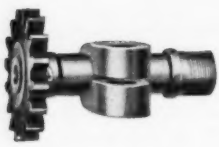


Fig. 565

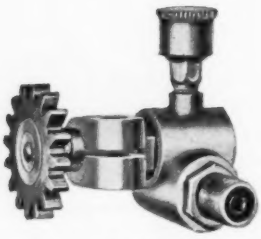


Fig. 566

Fig. 567

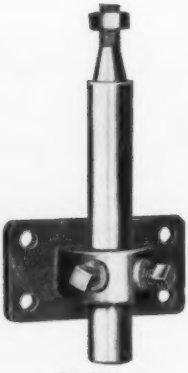


Fig. 568

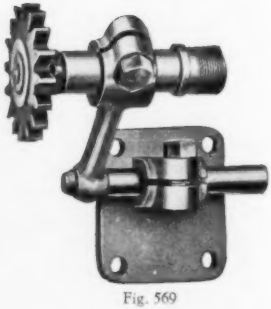


Fig. 569

STANDARDIZED TACHOMETER DRIVE FITTINGS

adapter which is made up in no fewer than fifteen different models with eight different speed ratios and with various standard cable end and engine end fittings. Figs. 562 and 563 show right-angle type single adapters, of which these are respectively eight and six models which come with various cable, engine and instrument fittings. The latter is especially designed for 90-degree turn at the instrument head. Fig. 564 shows a dual adapter whereby two instruments may be driven from the same speed take-off. It is made up in seven models, in ratios of 1:1, 1½:1, 1:2 or 1:3 and with various cable and engine fittings. Figs. 565 and 566 show two pinion drives, a straight type single and a right angle type single. Each is made up in five models with various ratios, etc. Fig. 567, 568 and 569 show three forms of attaching brackets, the last being shown with a straight type single pinion drive.

There are so many such specialties on the market that it is worth while investigating their possibilities before experimenting with home-made or non-standard devices of dubious serviceability.

12. Rotating U-tube

(This Section belongs with the others on centrifugal tachometers—7 to 14 inclusive—which appeared in the August number)

This class utilizes the same principle as that of the rotating liquid cup discussed in Section 11, but its actual construction for industrial speed measurement purposes is a far cry from the simple glass cup.

Although generally known as a U-tube, the principal element of tachometers of this class is a W-tube or a double U-tube (⊔⊔) with three legs instead of two. The principle remains that of the U-tube for measuring differentials: As the speed increases, mercury is forced outwardly from the axial leg to the revolving leg. This revolving leg is simply duplicated, so that it consists of two tubes instead of one, and the symmetry of the design results in dynamic balance, smooth running, and minimized wear. The level of the liquid in the center tube falls in proportion to the speed and a float transmits this motion to an indicating dial, to a recording pen or to both. Fig. 570 shows the general view of a mercurial U-tube tachometer made by the Amthor Testing Instrument Co. This instrument stands 40 inches high and its recording mechanism has a 6-inch diameter drum which takes a 24-hour chart 19 inches long and 5¼ inches wide, with a scale 4½ inches high.

Characteristics. (1) Rotating U-tube tachometers with floats measure speed continuously. (2) They can measure speeds over the widest range of any centrifugal class without need of gear shifts. Measurement starts practically at zero and the U-tube may rotate at up to 4000 r.p.m. While mechanical weight centrifugal classes are limited in their ranges of accurate measurement to a ratio of 1:4, or at most 1:12, the mercurial class will cover as wide a range as 1:400. In other words, for a scale graduated up to 4000 r.p.m., and without any gear shift, the lowest dependable graduation on a fly-ball, tilting-ring or cross-pendulum tachometer scale would usually be 1000 r.p.m. and at best about 100 r.p.m., whereas this class would have a scale starting at zero and on which a speed of 10 r.p.m. could be measured with a limit of error as small as that in other regions of the scale. (3) The temperature coefficient is usually almost negligible because it is the displaced mass that varies with the speed, so that since this mass varies inverse-

ly with temperature for equal volumes, and since the height in the outer legs varies directly with temperature for equal speeds, there is what nearly amounts to an automatic self-compensation. Other temperature effects are negligible. (4) This class can only be made up in stationary tachometers.

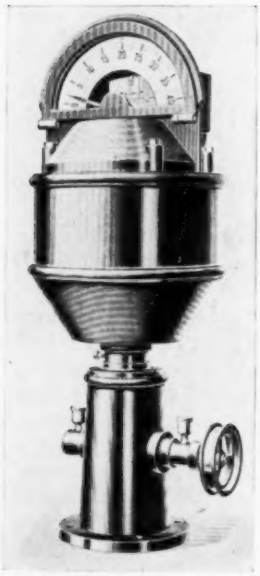


Fig. 570

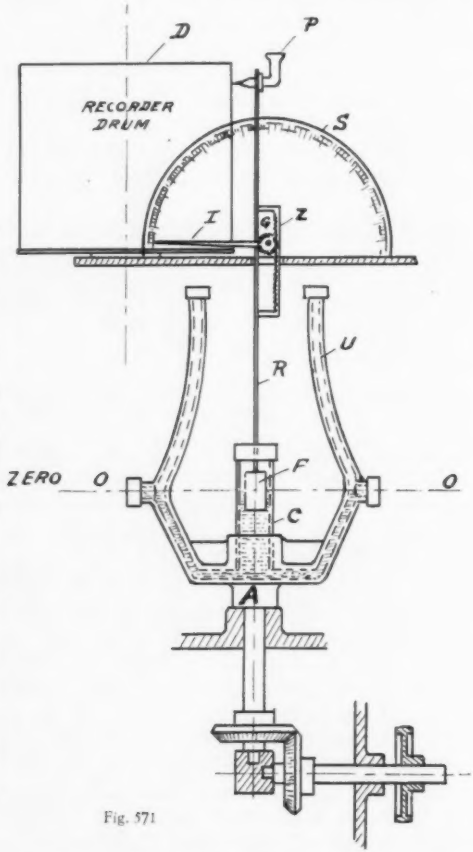


Fig. 571

(5) It is only represented on the market by comparatively large instruments. (6) Indications are steady. Slight rapid fluctuations in the measured speed are damped, and there is nothing to resonate at any frequency. (7) Lag is therefore appreciable but is is like true "thermometric lag" which does not affect sensitivity, rather than a form of sluggishness. The ultimate sensitivity of a large indicator in good condition can be within 5 r.p.m. on a 0-4000 r.p.m. scale 15″ long. The ultimate sensitivity of a recorder will depend on its construction and condition. (8) Accuracy depends in an indicator on the care with which the scale has been hand-calibrated. With the usual large scales the limit of error should not exceed 0.5% at any point. In the case of recorders where the float motion actuates the pen directly, the accuracy of recordings on standard printed charts will depend on the workmanship—the skill of the glass blowers in following the correct design of the U-tube, etc. (9) Adjustments are seldom necessary, in view of essential simplicity; care and maintenance are simple; most repairs,

however require manufacturer's own service. (10) No remote-reading systems; no multiple-indications. (11) Direction of rotation immaterial.

Fig. 571 is a schematic diagram of the Amthor instrument. The construction consists of a U-tube U with a center float tube C containing mercury to the zero level as shown in the sketch. Centrifugal effect forces the mercury into the outer legs of the U-tube, thus lowering the mercury level in the center float tube C. Float F follows the lowering mercury level of center tube, taking rod R with it. This movement of rod R is transmitted to the indicating pointer I through a rack and pinion, and to the recorder drum D through pen P.

The legs are so shaped as to decrease the radius of the circle described during rotation. This insures graduations nearly uniform over the scale.

There is so little clearance between the inner wall of the float tube C and the float tube itself, and the bore of the U-tube is so small, that there is no appreciable effect of the tendency of the mercury surfaces to assume the shape of a paraboloid of revolution.

18. Positive Pump Tachometers

This class is not represented at present in the United States by any complete commercial instruments that can be ordered from stock, and hence the discussion can be cut short. In general this class can be broadly divided into two types: the positive displacement pump tachometers, which employ the method of measuring speed by measuring the *volume* pumped per unit of time, and all others. These others would seem to belong in Section 13 but the *flow* of liquid is a factor here, whereas there is no flow at all in the self-contained centrifugal instruments such as the one described in Section 13.

Volume-pumpage or positive displacement pump tachometers, as implied by these terms, consist of a piston or other positive pump and of a rate-of-flow measuring instrument. This type therefore may be said to include all installations where advantage is taken of the fact that a positive displacement pump—*not* bought especially for tachometric use but already in service for another purpose—runs always at a speed which varies exactly with the speed which has to be measured. On all such industrial applications any suitable rate-of-flow meter can be installed and calibrated in r.p.m. of the machinery.

In one tachometric model, the Boyer, which is said to be used to a considerable extent in connection with locomotives, the pump, of the two-gear type, which is small and which has a positive volume displacement when handling light oil, is driven by gears, eccentric, or crank. The rate of flow of pumped fluid is measured in the following manner: the oil is forced into a cylinder where it displaces a piston against the pull of a spring. The oil escapes through an adjustable slot in the side of the cylinder. Since the volume delivered by the pump varies as the speed the piston must move upward to increase the size of the slot and the pressure to an extent sufficient to let the increased quantity pass. This device is subject to errors due to temperature and viscosity changes in the fluid. The mechanism itself must also be watched to guard against pump leakage, stoppage of the variable orifice, etc.

In other models of this volume pumpage type, air or other fluids are used with suitable types of displacement pumps. The range of operation should be over the upper 75 per cent of the scale. All bearings should be properly

lubricated. The accuracy depends upon the slip of the pump, the temperature, the viscosity of the liquid, and the freeness of the orifice, together with the accuracy of the measuring column or other form of flow meter as affected by temperature, etc.

These devices would seem to be dependable enough for exacting industrial purposes, but not accurate enough for applications where the limit of error should not exceed 3% of the scale range. It is worthy of mention here that while this type was listed in the abstract of the A. S. M. E. Code

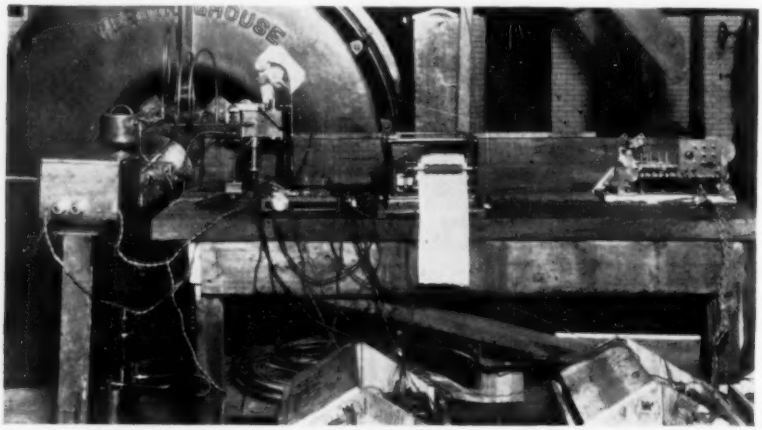


Fig. 572

(Part 13, Speed Measurement) published in *Mechanical Engineering*, April 1929, page 311, it was altogether omitted from the approved pamphlet of Part 13 which was issued in 1931.

From among "all others" we select as type example the Autographic Pump Tachometer, which is used for the testing of governors where extreme accuracy is required. This device, of which a set-up is shown in Fig. 572, was developed by Engineers of the So. Philadelphia Works, Westinghouse Electric & Mfg. Co. As mentioned above with regard to all tachometers of this class, this one is not a regular stock model available commercially, but it is interesting enough to rate a description here, and the following is abstracted from the aforementioned A. S. M. E. pamphlet:

This tachometer consists (see Fig. 573) of three main elements: the tachometer pump, the indicating mechanism, and an auxiliary or return pump. The tachometer pump is connected to the shaft the speed of which is to be determined. Oil is supplied to the pump from a reservoir in which a constant level of oil is maintained by means of a float. The discharge of this pump is connected to the indicating mechanism which essentially consists of a pilot valve responsive to changes of oil pressure, and a power piston under the control of the pilot valve. The motion of the power piston is transmitted to indicating and recording instruments by means of piano wire. To eliminate sticking and high static friction, the pilot valve works in a rotating bushing, which is driven by a motor. Pressure from the tachometer pump acts on the pilot valve piston just above the main spring and damper. The load on this is balanced by the main spring, against which is also acting the load due to the compensating spring of the pilot valve.

Upon change of speed, the increased pressure from the tachometer pump acts on the pilot valve piston, unbalancing the pilot valve, which moves until the spring load again balances the pressure. This admits oil to the power cylinder from the auxiliary pump, displacing the power piston. The movement of the power piston increases or decreases, as the case may be,

the tension on the compensating spring, which returns the pilot valve to the neutral position, thus arresting the motion of the power piston. The damper plate is necessary to prevent the entire moving system from oscillating or pumping at its natural frequency.

The auxiliary pump supplies oil pressure for operating the power piston, and maintains a supply of oil to the tachometer pump reservoir. All leakage and discharge from the indicating mechanism are conducted to the auxiliary pump reservoir. The various piping connections are indicated in Fig. 573.

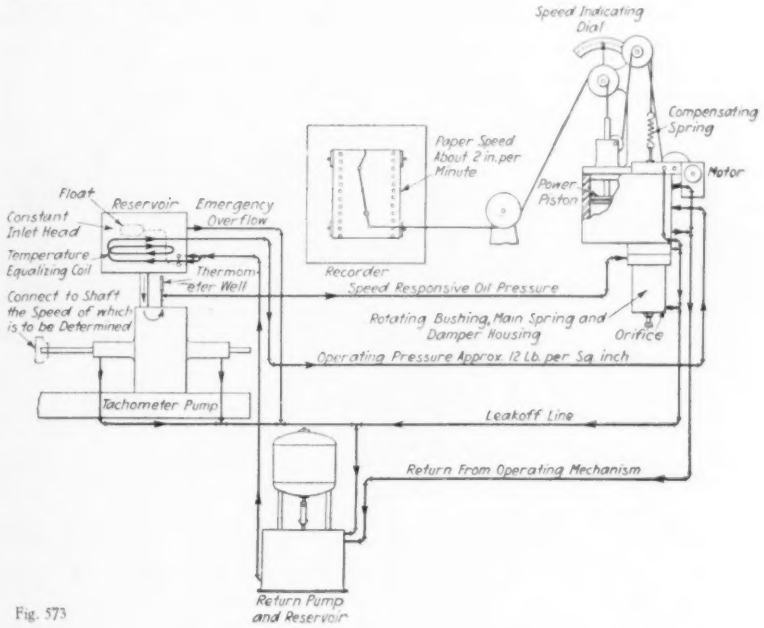


Fig. 573

A temperature equalizing coil is placed in the tachometer pump reservoir through which the indicating mechanism operating oil flows. There is also an orifice in the main pressure chamber of the indicating mechanism for the purpose of increasing the flow slightly through the tachometer pump and this part of the indicating mechanism. These features tend to maintain uniform oil temperature throughout the apparatus.

19. Miscellaneous Tachometers

There are of course many tachometers utilizing principles of speed measurement different from those to which sections have been assigned in this chapter, and their number increases from year to year, but most are of little industrial interest or of no interest to American engineers. Two instruments stand out sufficiently to be included.

(a) Inertia Wheel Tachometer

The Cowey (British) inertia wheel tachometer is intended primarily for automotive service. It embodies a milled edge wheel (Fig. 574*) which is rotated by impulses from a pawl mounted on a crank on the driving shaft. The wheel is drawn back in the direction of the zero stop by a restraining spring, but owing to its inertia the wheel only travels a certain distance in the interval of time intervening between two successive impulses. When

*Illustration, and abstracted description, from "Aircraft Instruments" by C. J. Stewart, Chapman & Hall, London.

a steady state has been attained the backward motion between the impulses must equal the forward movement caused by an impulse. If the speed of the shaft increases, the impulses occur at more frequent intervals and the forward motion by an impulse is not entirely wiped out by the backward movement in the interval before the next impulse, so that there is a progressive forward motion of the wheel until a position is reached such that the increased torque due to the restraining spring is just sufficient to cause

Fig. 574

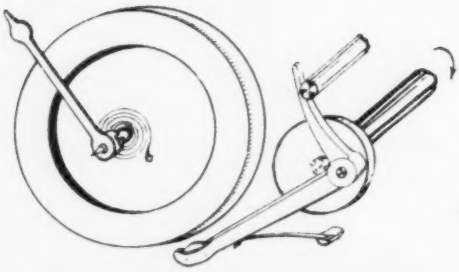
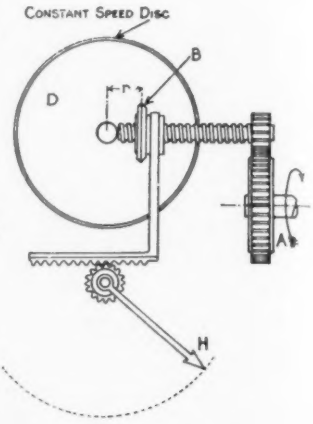


Fig. 575



the wheel to slip back by an amount exactly equal to the forward movement caused by an impulse. There is therefore a definite mean angular position for each speed, and the pointer is arranged with sufficient play to eliminate the oscillation of the wheel, while indicating this mean reading. The instrument is sensitive to fluctuations in the drive if this is of the flexible type, hence the drive should be of a type such as to avoid torsional oscillations.

(b) Friction-disk Tachometers

The Behrens (French) instrument is of this type. A bevel gear, driven from the engine in one direction only, causes the rotation of a ball-governor mechanism, which rotates at a definite speed a large friction disk, as in a phonograph. The bevel gear also drives through a train of gears a pinion secured to a hinged quadrant. By the rotation of this quadrant a small carriage, carrying a small friction wheel, moves radially across the face of the large friction disk controlled by the governor. The pinion carried by the quadrant and meshing with the gear driven from the flexible shaft is also connected by gearing with the small friction disk. The pinion when driven by the friction disk tends to carry the quadrant in one direction and the engine-driven gearing tends to turn the quadrant in the opposite direction. When these actions are balanced, *i.e.*, when the speed due to engine drive is correlated by positioning the radial-friction disk to a determinate surface speed of the constant-speed disk, the quadrant arm takes up a definite position which is indicated by the instrument pointer. The principle is shown diagrammatically in Fig. 575*. The pinion *A* driven from the engine drives

*Illustration, and abstracted description, from "Engineering Instruments and Meters" by E. A. Griffiths, G. Routledge & Sons, London.

through gearing a small friction wheel *B* running on the constant-speed disk *D*. The wheel *B* is positioned on the disk *D* so that its rotational speed due to the disk *D* is the same as that due to the engine drive. This action is indicated as being performed by a screw thread, although the actual instrument achieves the result by epicyclic movement. The position of *B* is then indicated by a pointer *H*. Instruments of this type are simple and are said to be accurate when in good condition but their accuracy is impaired after prolonged use. The employment of friction disks is generally objectionable.

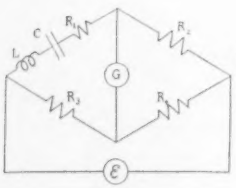


Fig. 576

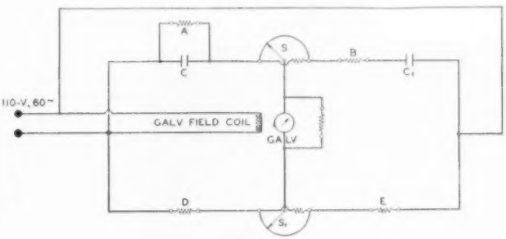


Fig. 577

20. Frequency Meters

Although frequency is almost synonymous with speed it connotes the time rate of recurrent events rather than the rate of motion. The vibrations of machinery, the alternations of electrical phenomena, etc., are expressed as frequencies and not as speeds. Measurement of mechanical frequencies or vibrations is discussed in Section 21. This section deals only with electrical frequencies, and only with industrial frequency meters that are related to the control of speed of machinery in plants and therefore belong in this chapter on speed measurement. Special high-frequency measurements, as in radio work, are excluded. Theoretical details are also relegated to the chapters on electrical instruments.

Frequency Bridges—The basic principle utilized in this general type of instruments is that any bridge in which the balance depends on frequency may be used to measure frequency. Fig. 576 shows one form. The balance conditions are

$$\frac{R_1}{R_2}=\frac{R_3}{R_4} \qquad \text{and} \qquad 1-L_1C_1\omega^2=0$$

where the *R*'s are resistances, *L* an inductance, C_1 a capacity and ω the measured frequency. The AC balance is independent of the resistance ratios and therefore the galvanometer scale can be calibrated in c.p.s. by using a variable inductance or capacity.

Leeds & Northrup Recorder—The circuit of this instrument, shown in Fig. 577, is that of an impedance bridge, two of the arms consisting of non-inductive resistances together with mica condenser units. One of these latter arms contains a non-inductive resistance in parallel with a mica condenser, and the other arm contains a non-inductive resistance in series with a mica condenser. The balance point of such a bridge is extremely sensitive to changes in frequency. The manganin resistance units are of L & N standard construction and the mica condenser units are identical with those

used in standard mica condensers. The resistance units have a temperature coefficient less than .002 percent per degree C and the condenser units of less than .01 percent per degree C.

The arrangement constitutes a balanced or null bridge in which changes in line voltage or changes in sensitivity of the galvanometer cannot affect the accuracy. The only contacts in the bridge are in the galvanometer circuit where variation in contact resistance can cause no error. The two moving

Fig. 578

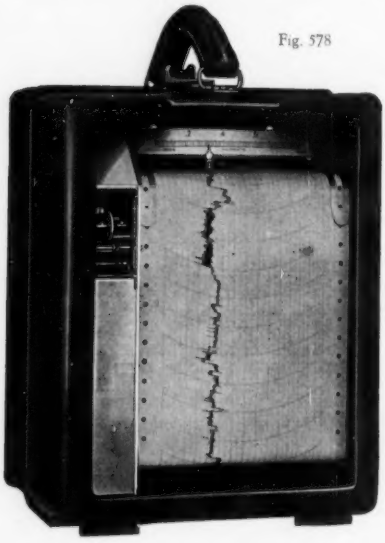


Fig. 579

contacts are mechanically connected and move together. One of these moves over a compensating resistance which makes the balance point independent of the phase of the current in the field coil.

The instruments are of standard L & N recorder form, similar in appearance to the speed recorder shown in Fig. 550. The galvanometer performs no work, a motor being used to move the recorder mechanism and to operate automatic control contacts (see Section 26).

Three ranges are regularly listed: nominal 25, 50 and 60 cycle circuits, all at 110 volts. For higher voltages, transformers are required. The power for operating the recorder mechanism and for driving the chart is obtained from a 110 volt, synchronous motor. Thus the chart drive on all recorders connected to one system will be at the same speed, even though there are departures from normal frequency. This permits a rigid intercomparison of the records obtained at different points on the system.

The charts come in 50-yard rolls, have rectilinear coordinates and are 10 inches wide. The standard 25 cycle chart has a range of 24 to 26 cycles. The chart for a normal 50 cycle circuit has a range of 48 to 52 cycles and the chart for a normal 60 cycle circuit has a range of 58 to 62 cycles. The chart speed in all cases is $1\frac{3}{8}$ inches per hour.

Leeds & Northrup Indicator—This is a new 9-inch round case switchboard instrument utilizing the same principle as the recorder and employing the same elements.

Esterline-Angus Recorder—This instrument, of which the portable form is shown in Fig. 578, utilizes a different general principle, the meter element, shown in Fig. 579, being of the dynamometer type. The moving system consists of armature coils mounted one above the other on a staff in planes approximately 90 degrees apart. One coil is excited by means of a current

passing through a condenser; while the other coil is excited by current passing through an inductance. When the frequency increases the impedance of the condenser decreases, permitting more current to flow through the coil connected in series with the condenser. At the same time the impedance of the inductance increases, reducing the current passing through the other movement. The result is that one movement becomes stronger and the other weaker. Since the moving coils are placed at 90 degrees to each other, they are caused to take up a new position where the torque of the two halves of the movement will again be in balance.

The upper and lower half of the movement operate in opposition to each other. As the instrument staff has no controlling springs, the pen takes a position fixed by the relative torque of the two halves of the moving element.

Since both the inductance and the capacity are affected alike by changes in voltage, the instrument is relatively free from errors due to changes in voltage. Of course, if the voltage is greatly reduced, the torque may drop to a point insufficient to move the pen across the chart, but the instrument is accurate with voltages 20% below or above normal.

The scale is 55-65 cycles, readable to 1/10 cycle. It is wider than those commonly used, especially below the normal values. This makes it possible to record the frequency during periods of serious disturbances when the frequency drops considerably. "We have found that there is no gain in accuracy by narrowing the range in order to increase the pointer movement for a given change in frequency, as the inherent errors are increased in the same proportion."

Frahm Resonance Type (*James G. Biddle Co.*)—This type is also known as the vibrating-reed type, which designation is descriptive of its construction. The measuring element consists of a row or "comb" of thin nickel-plated spring steel reeds, each about $\frac{1}{8}$ in. wide, rigidly fastened at one end to a bar of "bridge," their other ends bent at right angle and free to oscillate. Fig. 580 is a top view of this measuring element and Fig. 581 shows an individual reed and the cross-section of the bridge. Thus far, this is the vibration tachoscope (Section 21) but for electrical frequency measurement the bridge is attached to the armature of a small electro-magnet mounted close to it. When the instrument is connected across the circuit the frequency of which is to be measured, the current, after passing through a series resistance, excites the electro-magnet which thus imparts to the armature one impulse for each cycle of current if the core of the electro-magnet is a permanent magnet, and two impulses for each cycle if the core is of soft iron. That reed which has a natural period equal or nearly equal to the frequency of vibration of the armature will respond most vigorously, thus providing a *visual* indication. Nor recorders are available. The frequency instruments are of similar appearance to the tachoscope shown in Fig. 583 but most of them have two rows of reeds, 62 altogether instead of 31. The greater the number of reeds, the more closely is it possible to interpolate. Ordinarily, the range of a single instrument should not extend beyond one octave so that harmonics will not cause two groups of reeds to vibrate, but a range-doubling device, consisting of an additional electro-magnet with a permanent magnet core, gives a range of two octaves for one instrument. The value of the interval between frequencies of adjacent reeds is governed by the scale value and by the desirability of obtaining clear indications of small changes in frequency without having too many reeds in vibration. Below 30 cycles, for example, one reed is provided for

approximately 90 degrees apart. One coil is excited by means of a current

Fig. 580

Fig. 581

Fig. 582

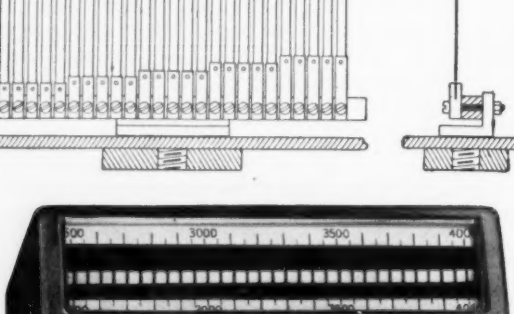


Fig. 583

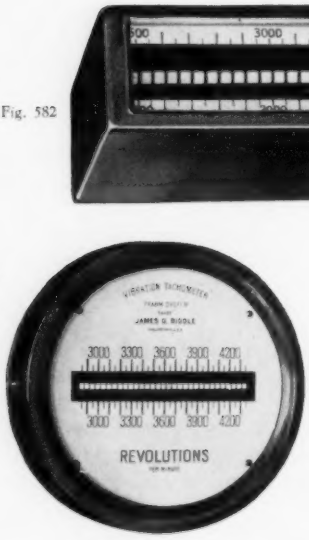


Fig. 584

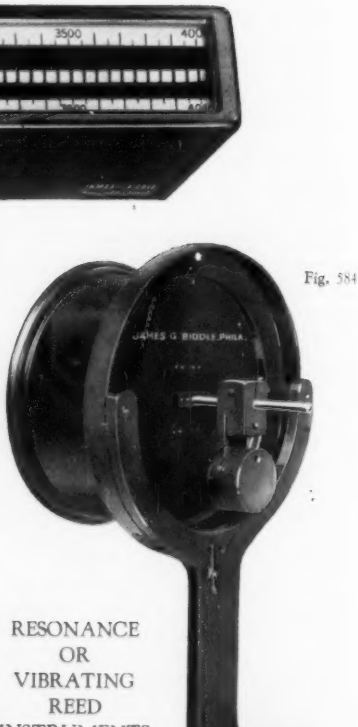
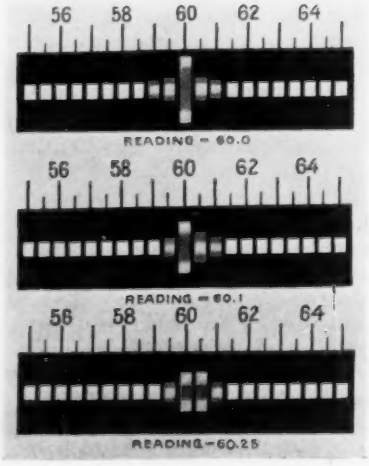


Fig. 585



RESONANCE
OR
VIBRATING
REED
INSTRUMENTS

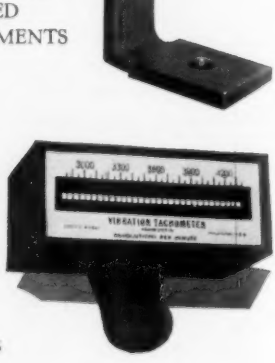


Fig. 586

every quarter-cycle, whereas for ranges approximately 120 to 200 there would be one reed for every two cycles. Contrary to usual belief that this type indicates only certain fixed frequencies, interpolation is easy, as is explained in the following statement by the makers:

"On first consideration it may seem that this method of indication is capable of giving results only in an intermittent, step-by-step fashion, as the number of reeds in one instrument is naturally limited, so that (apparently) indications depend on the chance of the frequency to be measured corresponding exactly to that of one of the reeds in the instrument. In practice this is not the case. The vibration of each reed is not confined to one mathematically exact value, but extends over a certain range of frequency. Vibration begins at about 2% below the exact value to which the reed is tuned, reaches its maximum at the exact value, and extends to about 2% above that value. Therefore more than one reed usually is in motion, and from the respective lengths of the bands formed by the vibrating-reeds across the scale opening the exact value of the frequency may be estimated down to one-fourth of the interval between successive reeds. Reference to the three different scale images in Fig. 585 will make this feature clear. On the upper scale the reading is evidently 60. On the lower scale, the reeds indicating 60 and 60.5 are vibrating equally, so that the reading is *half way* between these two values,—that is, 60.25. Referring to the middle scale, it will be seen that the reed indicating 60 is vibrating more than any other, so that the reading is therefore nearer to 60 than to any other scale division. Furthermore, the reed indicating 60.5 is in next greatest vibration, so that the reading is again between 60 and 60.5. However, the reed indicating 60 is vibrating with an amplitude about three times that of the reed indicating 60.5, so the reading is now *one-quarter way* from 60 toward 60.5 instead of one-half way. That is, the reading is 60⅛ or approximately 60.1."

The accuracy of each individual instrument depends on the tuning of every reed in its comb, so that any statement giving the definite limit of error of this type would seem to be rash. It is certain, however, that severe service makes an individual reed lose its calibration so that each instrument tends to lose its accuracy first at the very region of its scale which includes the normal value of the measured frequency.

Stroboscopic Frequency Meters—Certain forms of stroboscopes can be used for frequency measurements. See Section 22.

21. Vibration Tachoscopes

In this class of speed measuring instruments, exactly the same principle is utilized as in the resonance type of AC frequency indicators, but the excitation of the reeds is purely mechanical. An important characteristic, therefore, is that the instrument must be placed in mechanical contact with the machine the speed of which is to be indicated. When a machine is so well balanced as to vibrate almost imperceptibly, the instrument may be mounted on a special bracket and with an amplifying attachment, see Fig. 584. The range of this class extends from about 800 to about 12,000 r.p.m. The range of an individual instrument should usually be limited to one octave, that is, its scale should be such that the value of the highest graduation will not exceed twice that of the lowest. Figs. 582-3-4-6 show various forms of the Frahm instruments (J. G. Biddle Co.) for different purposes. The hand tachoscope shown in Fig. 582 weighs 20 ounces; the regular 9-inch case instruments, Fig. 583, come with one or two rows of reeds; the new rectangular form, Fig. 586, saves space. Indicators made up with one row have 31 reeds, those with two rows have 62.

The ultimate sensitivity is usually one-fourth the interval between adjacent reeds. See discussion in small type in Section 20.

As to accuracy, the same remarks made with reference to resonance frequency indicators apply here, and there must be added mention of the fact that whereas it is possible to regulate the voltage and hence the am-

plitude of vibrations in the electrical type by means of a rheostat in the circuit, it is more difficult to guard against excessive vibrations in this mechanical class. The makers therefore provide special padded damping bars. *Initial* accuracy is *usually* well within 20 r.p.m. for low ranges, and within 2% of the measured value for high ranges.

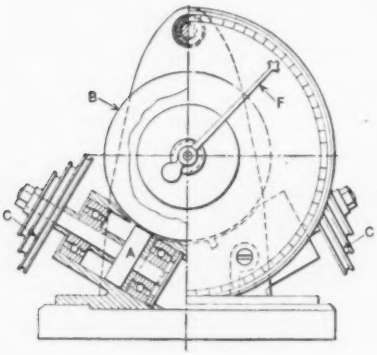


Fig. 587

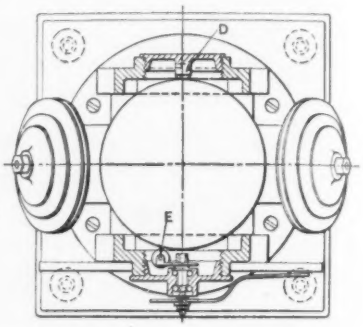


Fig. 588

24. Measurement of Differential Speed

On several classes of industrial application, of which the manufacture of paper is an example, it is necessary to measure the difference between the speeds of two related pieces of machinery in addition to measuring the speed of one or both. In some cases the differential is a more important factor than the speed, and must be measured continuously.

Electrical means of measuring this difference afford by far the widest applicability to industrial machinery. The principle of measurement is simple, consisting usually in the opposition of emf's. The generators, and the indicating and recording instruments themselves, are exactly like those described in Section 15. Potentiometer recorders in particular have been used with satisfactory success.

Mechanical instruments are somewhat more limited in their applications. One such device, for differential between two rotating parts, is shown herewith. Fig. 587 is the front view in part section and Fig. 588 is the top view, also in part section.* This indicator operates on the differential principle. It is equipped with two cylindrical rollers; one roller is shown at *A* and the other is located in a similar position on the opposite side of the vertical center line. The axis of the roller shafts are in the same vertical plane, and on the ends of these shafts are mounted belt pulleys *C*. These pulleys are connected with the shafts the relative speeds of which are to be compared. Each roller *A* is in contact with a spherical steel ball *B* three inches in diameter. The ball is held in position by a small stop *D* at the rear and by a small roller *E* at the front. This roller is mounted on an arm fixed to a spindle which is free to rotate and to the outer end of which is attached the pointer *F*. When both the supporting rollers *A* are driven at the same speed and in the same direction, the spherical ball will rotate about a trans-

*Illustrations and description from "Ingenious Mechanism for Designers and Inventors" copyrighted by The Industrial Press, New York.

verse horizontal axis and will carry the wheel *E* vertically up or down, as the case may be. The direction of movement will be indicated by the pointer *F*.

If either of the supporting rollers runs faster than the other, the ball will rotate about some inclined exis and wheel *E* will naturally turn so that its axis is parallel to that about which the sphere rotates. This instrument is said to be very sensitive as an indicator of speed variations. For instance, it is claimed that a difference in the speed of rollers due to a variation of 0.001 inch in the diameter of driving pulleys having a nominal diameter of 2½ inches can be detected.

This Chapter will be concluded in the November issue, in which the following sections will appear:

22. Stroboscopes
23. Chronographs and Oscillographs
25. Accelerometers
26. Automatic Speed Control

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

PRINCIPLES OF ELECTRICITY. By *Leigh Page and Norman Ilsley Adams, Jr.* D. Van Nostrand Co., Inc., New York, 1931. Cloth, 5½ x 8½ inches. 620 pages. Price $4.25.

There has long existed a clearly defined need for a text book on electricity, magnetism, radiation and high frequency oscillations—that is to say the broad subject of electromagnetism—to fill in the gap between what might be called high-school books and the highly specialized treatises that require thorough knowledge of higher mathematics. This book meets this need splendidly. It only requires that the student shall have completed the usual general courses in physics and in elementary calculus. This is a distinct advantage. Not only should educational institutions welcome this volume, but many practicing engineers and research workers will undoubtedly find it to be the sort of work they have been looking for.

The authors state in their preface that "While the relativity principle—so intimately connected with electromagnetism—is not mentioned *per se*, the point of view of that theory is maintained throughout." It seems to be quite an achievement to do this without recourse to the Tensor Calculus, but the authors have done it and they have gone so far in that direction that one looks in vain in the index for the name Einstein and for the word Relativity. It would indeed seem that what the authors have in mind when they mention "the relativity principle" in their preface is not Relativity. This hypothesis is bolstered by a cursory reading of several chapters where one expects to find that "the point of view of that theory is maintained throughout." One does not find this promise fulfilled entirely.

Returning to our comment on the simplicity of the mathematical treatment, mention must be made of the felicitous manner in which the subjects that come under "Magnetic Field of a Current" (Chapter VII) are introduced: the explanation of scalar and vector products and the development of short-hand notation for the latter, are delightfully lucid. Students can assimilate these few pages without mental sweating and thus equipped with the requisite tools they are ably conducted through Ampère's Law, magnetic fields and shells, and the measurement of a current by the interaction between the current and a magnet—that is to say the theory of galvanometers, their classification, etc., which is presented with great clarity.

No attempt is made to go into the constructional details of electrical instruments but the underlying theory of all important types is thoroughly expounded and convincingly developed. In fact, eleven of the seventeen chapters are devoted largely to the theory of measurements, and there is an adequate scattering of notes on laboratory practice. Librarians and reference compilers should make it a point to list this book under "Electrical Measurements" as well as under several other highly appropriate headings. The book thorougaly explains the principles and methods of measurements of resistance and absolute resistance, capacity and absolute capacity, frequency and high frequencies, permeability, inductance, etc.—to name only a few magnitudes. Chapter XI on Flux Measurement appears to be particularly well done, at least in the opinion of one principally interested in instruments.

The entire arrangement of the book seems to be unique in that whole chapters can be omitted for academic purposes in schools where courses must be fitted into one another. Thus it is possible to take up magnetostatics (Chapter IV) before electrostatics (Chapters I, II an III) by reason of the fac t that the main deductions of the first three chapters are briefly repeated in the fourth.

Chapter XII, on absolute standards and units, deserves special mention in a review for the readers of *Instruments*. It starts off with electrodynamometers and after explaining absolute measurements takes up the relation between the e.s.u. and e.m.u. and winds up with a useful set of fundamental equations.

From there on the remaining chapters are for advanced students and specialists. There is an up-to-date approach to the application of circuit theory to networks, filters and lines. An excellent introduction is provided to the advanced mathematical methods in general use in the field of electrical communications; also to high frequency oscillations and electromagnetic waves. The subject of photoelectricity seems to have been slighted, but perhaps the authors deliberately excluded it as not belonging in a text book on electricity. Not a word on Einsteins' photoelectric effect, but perhaps this is being reserved for another book. On the whole one does gain the impression of a systematic treatment with a definite purpose—to fill a clearly defined need as mentioned at the start—and no doubt to fit a definite place in the "University Physics Series" of which Dr. Page himself is the Consulting Editor. The worn phrase "a workmanlike job" characterizes this book.—M. F. Béhar.

Flow and Measurement of Air and Gases. *By Alex B. Eason.* Charles Griffin & Co., Ltd., London 1930; Cloth, 6 x 9 inches, 254 pages. Price 25 shillings.

This is the second edition of Eason's unique compendium. The first was issued in 1919, at a time when there was no text book dealing with this class of subjects. The appearance of several books in the meanwhile—including Ower's "The Measurement of Air Flow" now appearing serially in *Instruments*—has not diminished the value even of Eason's first treatise; and certainly this new and expanded work should prove all the more valuable to advanced students and practicing engineers alike. For the benefit of those unacquainted with Eason's original book it may be said that it is a systematically arranged and, even now, by all odds the most highly documented review of investigations of air and gas flow ever assembled between the covers of a single book.

An excellent feature of the book is the profusion of nomographs (which are styled "abaci"). Another is the employment of a useful device to relieve strains on the memory by making the tables of symbols visible while the formulas are studied: At the end of each chapter there is inserted a double-page which can be opened up. On the outer half of each of these sheets is printed the notation used in the chapter to which it refers.

In this connection it must be pointed out that American engineers interested in air and gas measurements will find it somewhat irksome to be forced to convert altogether too many Metric unit data into the English units which are practically exclusively used here. After all, it may be true that Frenchmen were the first to develop the fundamental equations of flow metering but nearly all of the really important modern work has been done by Americans and Englishmen. English-speaking engineers are therefore entitled to some consideration!

Another thing at which American engineers will raise surprised eyebrows is Eason's neglect to consult for his revision more American references than he actually did—according to his own lists. In his first edition it was evident that he spared no efforts to get at the best which the United States had to give at that time—1919 . . . which was not so much then. But in 1930, after a decade that has witnessed enormous progress in theory and practice on this side of the Atlantic, he appears to be serenely oblivious of most of what we have done in air and gas research, engineering, instrumentation and practical applications. For instance he states in the preface to the revised edition, "After perusal of technical literature, one feels that Chapter XI, on orifice flow, only touches the fringe of the subject. To deal properly with the matter would need a treatise somewhat like various numbers of the *Forschungsarbeiten* of the Verein Deutscher Ingenieuren." What about our own engineering societies? What about the laboratories maintained by some of our corporations? Why, nearly all recent progress in orifice metering is star-spangled. And when it comes to natural gas measurement research—largely orifice work too—half a dozen American specialists could be matched against all of Europe's put together.

For all that, Eason's work stands out none the less as a towering masterpiece of logicaly organized documentation. Scores of closely printed pages of correlated abstracts of phamphlets and articles testify to his untiring diligence. The reader, going through this book and coming across these evidences of patient zeal combined with a talent for summarization, begins to wonder whether this volume was produced by one man or by a committee. Eason's gift for correlation and coordination, together with his obvious mastery of all underlying scientific principles, has resulted in a work to which the reviewer is forced to apply the shopworn qualification: "a mine of information." There is the difference, though, that the mine shafts and galleries have all been dug so ably that the reader himself need never dig laboriously but can always pick up with ease.—M. F. Béhar.

Optical Activity and High Temperature Measurements. By *F. M. Jaeger.* McGraw-Hill Book Company, Inc., New York, 1930. Cloth, 6 x 9¼ inches, 450 pages, 137 figures. Price $4.00.

This book is essentially a reprint of the lectures delivered by Professor F. M. Jaeger of the University of Gröningen, at Cornell University, during the second semester of 1928-29, under the George Fisher Baker Non-Resident Lectureship in Chemistry.

It is the custom to introduce these annual lectures by a lecture devoted to some topic of general interest which in this case is a discussion of the present and future state of our natural resources. A brief account is given of the energetic and material resources of nature, the former being represented by the natural stores of energy that can be utilized directly for the production of mechanical force, and the latter being represented by minerals and metals.

There are three series of lectures. The first is concerned with spatial arrangements of atomic systems and optcial activity; the second with the methods, results and problems of precise measurement at high temperature; and the third with the constitution and structure of ultramarine. For the most part the investigations preceding the lectures were carried out by Professor Jaeger and his co-workers in the chemical laboratory of the University of Gröningen.

The first series give a general discussion of our more recently acquired views on the relations between geometrical and physico-chemical properties of atomic systems occurring in inorganic and organic molecules. After a brief review of the discovery of the facts summed up in Pasteur's Law, the author illustrates how the principle of symmetry can be utilized in problems dealing with the possibility of separating optically inactive substances into their enantiomorphous antipodes. The historical role of Le Bel and van't Hoff is emphasized. Theoretical views are given on the chemical structure of complex inorganic salts and the basis on which our ideas of their spatial arrangement is founded. The possibility of effecting a totally asymmetrical photosynthesis is discussed with emphasis on the significance of this problem in the synthetic processes of nature.

The second series first takes up the principles and problems involved in high temperature measurements up to 1650°C. which is of extreme importance in the ceramic, glass and metallurgical industries. After discussing the development and refinements of the measuring methods at high temperatures and some of their applications the author says on page 249, "It would be interesting, at this date, to reinvestigate a number of phenomena of binary and ternary metallic systems, applying the modern improved methods. This might develop many new and surprising facts and phase-transitions which so far have escaped observation by the cruder methods heretofore employed. Such work might prove to be of the greatest importance for the metallurgical industries also." The methods and equipment for the accurate determination of the temperature coefficient of the surface tension of liquids between —80° and +1625°C. is especially interesting. The methods, equipment and results at high temperatures are given for specific gravity and viscosity determinations, the measurement of the electrical conductivity of molten salts which is especially difficult above 700°C. and the measurement of the internal friction of molten salts. On the important topic of the precise measurement of the specific heat of solids up to 1650°C. many practical points are discussed and considerable data is included.

The third series is a discussion of the constitution and structure of ultramarine and gives the results of investigations recently carried out at the University of Gröningen.

The contents of this book should prove of inspirational and material value to students of physics and chemistry at large and the second series of lectures should be of particular interest to those metallurgists who are interested in fundamental research. The author's easy style, versatility, natural familiarity with the work which he has directed and inclusion of many data tables make the book valuable for general information and reference.—O. O. Miller

NEW INSTRUMENTS

Recently Developed by Instrument Manufacturers

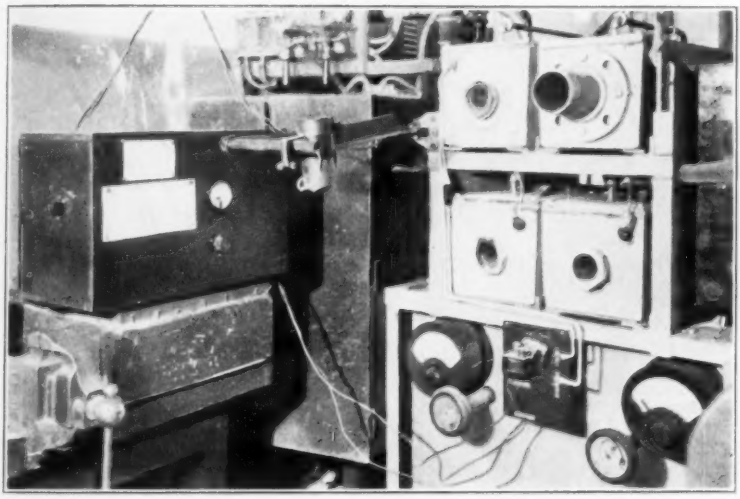
Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional information.

Photo-electric High Temperature Measurement and Control

THE photoelectric tube can be used for measurement and control of high temperature furnaces; when the temperature rises to the desired limit, it operates a thyratron tube which cuts off the current or fuel supply. Thus another addition is made to the list of uses for both the thyratron and the photoelectric tubes.

In the past it has been difficult to read the high temperatures required in special furnaces used for industrial and laboratory purposes, and it has been exceedingly difficult to control these furnaces or maintain a set temperature.

At the meeting of the American Chemical Society in Buffalo on August 31, Dr. L. R. Koller, of the General Electric research laboratory at Schenectady, announced a solution for the problem in using the photoelectric tube to measure the visible energy radiated by the hot body, and thereby its temperature. The photoelectric tube, with a suitable optical system, looks at the furnace wall or some object in the furnace. The current through the tube depends on the amount of light falling upon it, and accordingly varies with the brightness of the surface observed. Since the radiation from a hot body varies much faster than its temperature, the photo current is a very sensitive measure of temperature.

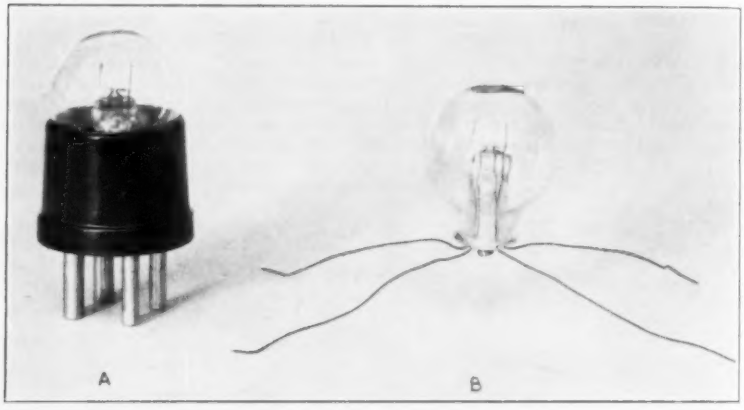


The photoelectric current is amplified by means of vacuum tubes and recorded on a meter calibrated in terms of temperature. The same current operates a thyratron tube, and the latter acts as an extremely sensitive relay which controls the supply of fuel or electricity to the furnace. The photo tube pyrometer described by Dr. Koller can be used at temperatures as low as 1000°C., and has no upper limit. It does not deteriorate due to the action of any products in the furnace, nor is any part of the apparatus itself in the furnace. It is instantaneous in its action, is very sturdy, and has no delicate moving parts. A single pyrometer reading supplies the calibration necessary from time to time. The control mechanism may be varied to suit individual needs, and by the use of two thyratrons, both upper and lower limits of temperature may be set.

The apparatus includes a long photoelectric tube housing mounted on a hinged bracket which the operator can swing to one side in order to get at the furnace. As much as three or four feet may separate the tube from the furnace proper. The bracket is provided with a worm gear for ease in making adjustments. A small opening in the housing makes it possible to observe a light spot and make sure that it is centered on the diaphragm placed in front of the tube.

New Vacuum Thermocouple for Alternating-Current Reading

BY means of a new vacuum thermocouple announced by the General Electric Company, it has become possible to measure accurately alternating current of any frequency with a sensitive direct-current instrument. The copper-oxide rectifier, ordinarily employed for such measurements, is less sensitive, cannot be used with current of high frequencies, and its accuracy is seriously affected by the wave form of the alternating current being measured.



Vacuum Thermocouples. A—Mounted in UX base. B—Unmounted.

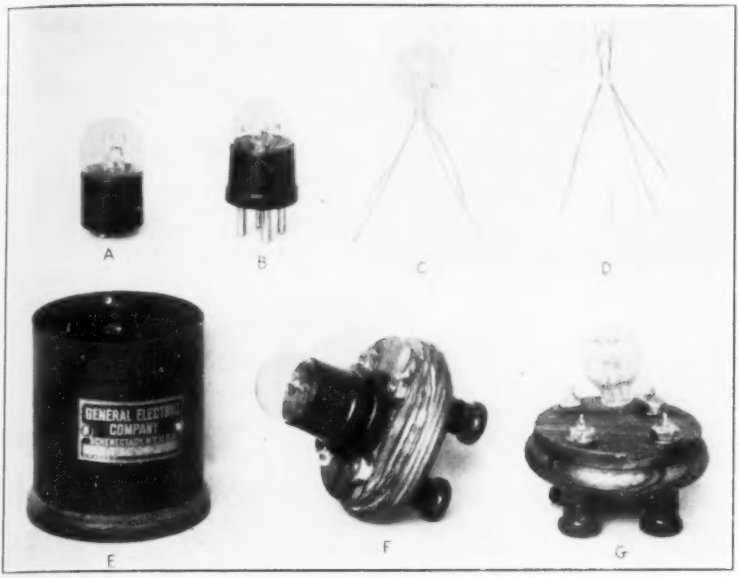
The thermocouple consists essentially of a heater wire and small thermocouple sealed in a vacuum bulb. The voltage developed in the thermocouple by the temperature rise of the heater wire, which is read on the direct-current instrument, bears a definite relation to the current in the heater wire.

The device is contained in a tipless lamp bulb with a four-prong UX-type base. It can be mounted in portable instrument cases where a space only 1½″ in diameter and 2″ deep is available. The thermocouple can also be furnished in a metal container with a wooden base and cover, to shield it from light and from sudden temperature changes when it is to be used externally.

Frequency errors in the audio-frequency range (up to 10,000 cycles) can be neglected in using the instrument. For the best accuracy in the radio-frequency range, the couples should be unmounted. In most cases, the thermocouples are sufficiently accurate on direct current without taking the average of direct and reversed readings.

There is little change in the calibration of the thermocouple if the maximum safe current is not exceeded. The thermocouples are designed to give maximum watts output with minimum watts input to the low resistance heater. An average value of the temperature coefficient of resistance of the thermocouple wires is +0.00009 ohm/°C. The self-heating and ambient temperature errors are small. The change in the open-circuit e.m.f. due to change in ambient temperature is less than 0.2%/°C.

The approximate constants for each type of the Type A Vacuum Thermocouple are shown in the table below. The millivolts are for the open-circuit couple voltage; the maximum heater current is the maximum safe continuous rating; and the fusing current is the approximate current required to burn out the heater in less than one minute.



Type A Vacuum Thermocouples and Container. B—Thermocouple with UX base. C—Thermocouple without base. D—Thermocouple mounted before sealing into the bulb. E—Thermocouple container without cover. F—Container Cover with Receptacle and UX Thermocouple, with UX base in place. G—Container Cover and Thermocouple, without base, attached.

HEATER MILLIAMPS.

Type	Heater Ohms	Couple Ohms	For 5 mv.	15 mv.	Maximum	Fusing
A-2	14	14	13	25	40	100
A-3	400	14	2	4.5	8	100
A-4	40	14	5.5	10	20	40
A-5	5	7	25	50	100	275
A-6	2.5	7	55	110	200	450
A-7	1	7	125	250	400	900
A-10	800	14	1.3	2.9	4	30

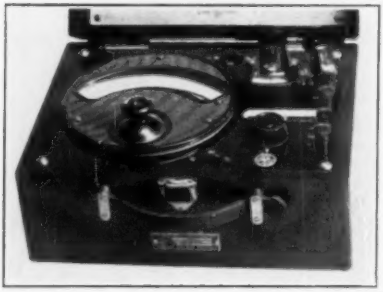
From the above table of resistances and open-circuit couple volts, the proper couple can be selected to give the required range of the galvanometer or instrument with which it is to be used, the resistance and current range of the indicator being known.

Thermocouples having special ratings can also be supplied.

Thermocouple Potentiometer

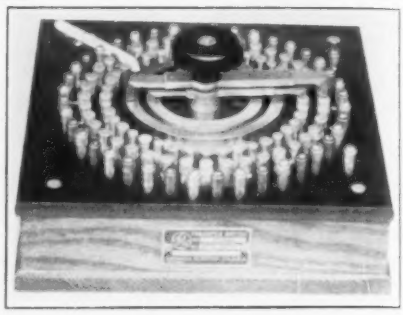
A NEW type of thermocouple potentiometer has been announced by the General Electric Company for accurate temperature measurements. Designated as Type PJ-1, the instrument works on the principle of a fixed current through a variable resistance, the unknown e.m.f. being balanced against the voltage drop of a variable current through a fixed resistance. The reading is then obtained by measuring the current with a Type DP-2 instrument. The principle overcomes the need for a standard cell, which requires frequently balancing to make certain the potentiometer current has not varied.

The scale of the 500-microampere Type DP-2 instrument reads up to 6 millivolts. A switch multiplies the scale values by 1, 5 or 10, thus making full-scale values of 6, 30 and 60 millivolts. There is also a temperature scale reading from 0° to 140°C., for use only when the G. E. copper-Copnic thermocouple is used with the 6-millivolt scale.



At Left—Type PJ-1B Thermocouple Potentiometer.

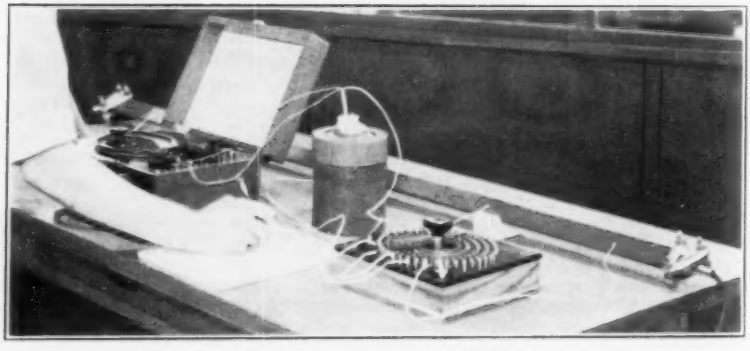
Below—Transfer Switch.



A cold-junction compensator knob, mounted on the metal cover of the microammeter, is used to set the needle at a temperature or millivolt value corresponding to the temperature of the cold junction. A thermometer is mounted on the panel to determine the cold-junction temperature when an ice bath is not used and the potentiometer is being used without a transfer switch. A battery switch on the panel is used to open the battery circuit and thus avoid deterioration of the battery when the instrument is not in use.

The potentiometer case, of walnut, measures 12 by 9 by 16 inches. Two flashlight dry cells are mounted in the bottom; all other parts are on the panel.

The potentiometer is self-contained for use with a single thermocouple, but when measurements are to be made with a number of thermocouples a transfer switch should be used. A transfer switch of General Electric manufacture has 20 pairs of terminals, all mounted in the top of a panel, making it possible to have all the internal connections of rigid, short heavy leads. The live contacts are separated by blank contacts, making it impossible to short-circuit adjacent thermocouples. Copper wires are used for connections between the transfer switch and the potentiometer. The cold junction temperature should be read from the thermometer in the transfer switch.



G-E Type PJ-1 Thermocouple Potentiometer being used to measure temperature of copper bar.

For precision temperature work an ice bath should be used for cold junction temperatures. One ice bath between the transfer switch and potentiometer is sufficient for all thermocouples.

The positive wire of the thermocouple is of copper; the negative wire is of Copnic (nickel, copper, iron and magnesium). The thermocouple is accurate within a half degree between 0° and 150°C. Each wire is enameled and insulated with cotton, then cabled with a cotton insulation, and further protected with white, flame-proof paint.

New Flow Instruments

(C. J. Tagliabue Mfg. Co.)

THE rate of flow in pipe lines follows the square-root of the differential pressure created at the orifice. There has been an active need for flow controllers that will do more than simply record differential pressure with the use of progressive charts for the rate of flow. With the so-called square chart the graduation becomes progressively wider from center to outside. Thus it is apparent that the accuracy, readability and controllability will be less and less as the rate of flow decreases. Although an instrument may function satisfactorily within its allowable tolerance, at the higher rates of flow, it is particularly important that inaccuracies do not increase at medium and low rates of flow to the same extent that the graduations are compressed. Control work, particularly, demands good accuracy for any rate of flow and this can be accomplished by the use of a chart reading directly in rate of flow but uniformly graduated, like the one shown in Fig. 1. This uniformity of graduations is made possible by the special design of the differential pressure gage—one leg of the manometer being made progressively smaller in diameter so that the curved cross-section of this leg produces uniform rise and fall of the mercury in the other leg and uniform motion of the float per increment of change in rate of flow.

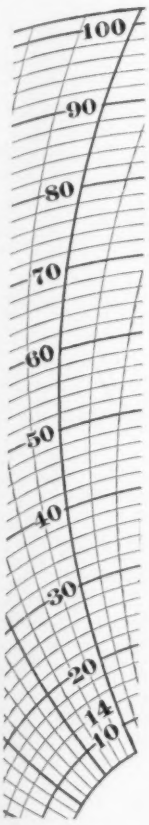


Fig 1

Among other noteworthy features is the method whereby a pressure-tight bearing is eliminated in transmitting the float movement from inside of the manometer pressure-chamber which is at pipe line pressure to the recording pen outside which is under atmospheric pressure, without friction or leakage.

The lever 51, which transmits the vertical movement of the float, engages yoke 67. This yoke is supported in position by two bellows 65

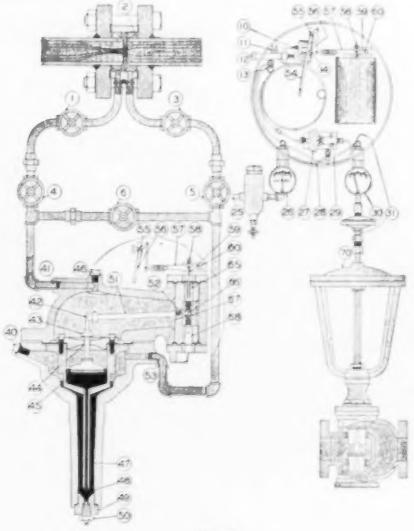


Fig. 2

and 68, one at each end. These bellows being identical are equally affected by pressure changes inside or outside the pressure chamber and balance each other so that such pressure changes can cause no movement of this yoke. At the same time they allow the yoke to move without any restriction up or down as the float falls and rises. The yoke extends through the

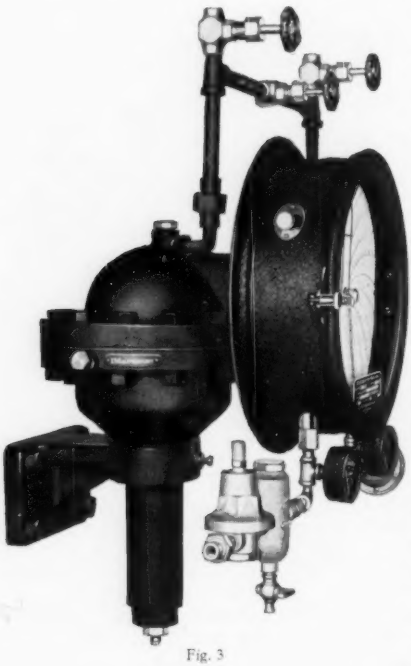
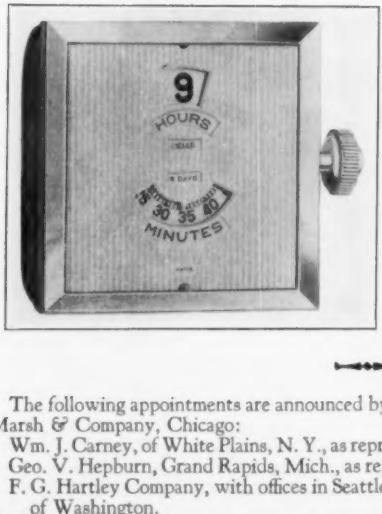


Fig. 3

inside of the upper bellow 65, enabling its motion to be communicated to the pen leverage system by pin 59. This construction eliminates friction and avoids any opening through the pressure chamber which is sealed from the atmosphere. A mercury blow-out check is provided, by the top of float 45 and the bottom of disc 43, which closes passage 44 at the limits of normal float travel. It acts automatically to prevent blowing out of the mercury in the differential pressure gage should there by a sudden surge or an accidental disconnection of one of the orifice pressure lines.

The TAG balancing control feature is incorporated as standard equipment and insures full-floating action of the diaphragm valve and entirely eliminates over-control tendencies and "hunting." This development furnishes 100% automatic control by its ability to maintain the diaphragm valve opening at the required demand point over the full range of valve opening. It also permits the operator to change the setting point anywhere within the range of the controller without fear that the controller will "go into a swing." The balancing feature enables the controller to quickly and smoothly change the diaphragm valve opening to the new demand point—and hold it there without "hunting."

Novel Automobile Timepiece



THE Jaeger Watch Company, Inc. have just announced the addition to their line of a new and quite novel 8 day automobile timepiece. This timepiece, known as the JUMP hour clock, tells at a glance, the exact time in hours and minutes.

The JUMP hour clock comes in either a dull nickel or chronium case, which is set off by a beautiful silver rippled dial. The case is so constructed that overhead installation above the windsheild is quickly and neatly accomplished. From this vantage point, the time is not only available to the driver but to every car occupant.

The following appointments are announced by A. D. Rose, general sales manager of Jas. P. Marsh & Company, Chicago:

Wm. J. Carney, of White Plains, N. Y., as representative in the Westchester, N. Y. district.

Geo. V. Hepburn, Grand Rapids, Mich., as representative in Grand Rapids territory.

F. G. Hartley Company, with offices in Seattle and Tacoma, as representatives in the State of Washington.

The Marsh Company, which is a division of the Commercial Instrument Corporation, Chicago, manufactures steam specialties, and industrial instruments.

Air Operated Recorder Controller

THE Bristol Company is offering a new line of air operated recording controllers, employing a "Free Vane" as the initiator of control, which is a new departure in air operated control.

The "Free Vane" is attached to and actuated by a measuring element of a temperature or pressure recorder and moves between two air jets with stream lines coinciding and placed opposite each other. In passing into these air streams, the "Free Vane" varies the amount of air which escapes from the jets, thus effecting control.

The arrangement and design of the two jets and the free vane are such that the vane floats between two equal air streams at right angles to its motion, hence the position and movement of the measuring elements are not affected. The recording device is, therefore, free to re-produce the temperature or pressure with complete accuracy.

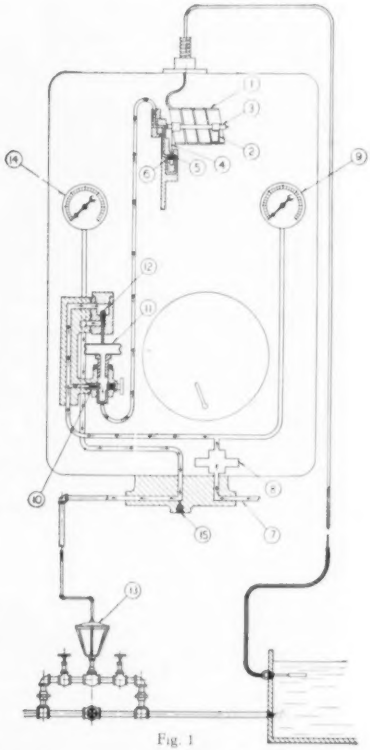


Fig. 1

Control from a frictionless device as described above permits the use of supersensitive measuring systems. With this sensitive measuring system are also co-ordinated the other features of ruggedness and simplicity.

The component parts are easily accessible although compactly assembled. The point of control is easily set to a visible scale point by means of a key.

Referring to the sketch (Fig. 1) the operation of the free vane air operated recording controller is as follows—

Air at 15 lbs. pressure is admitted through connection (7) and carried through filter (8), one branch leading to an indicating gage (9). The other branch turns to the left and supplies air to the control system. This supply branch in turn divides into two branches, one passes through an orifice (10) supplying the elastic element (11) and then through a connecting line to the opposing jets (5) and (6). The other branch supplies air to the pilot valve (12) and through the pilot valve to the indicating gage (14) and outward to the top of the diaphragm motor valve (13).

The air which enters through orifice (10) is dissipated through jets (5) and (6). The amount which may be dissipated through these jets depends upon the position of the free vane (4). This vane, being directly attached to an elastic element (1) of the hollow helical type, is moved by changes in the temperature at the sensitive bulb shown in the bath at the lower right hand corner. The changing amount of dissipated air at jets (5) and (6) produces a pressure change on the elastic element (11) and a consequent deformation which operates pilot valve (12) admitting more or less air to the top for operating the diaphragm motor valve (13). The elastic element (1) also carries the recording penarm which is attached to the shaft (3).

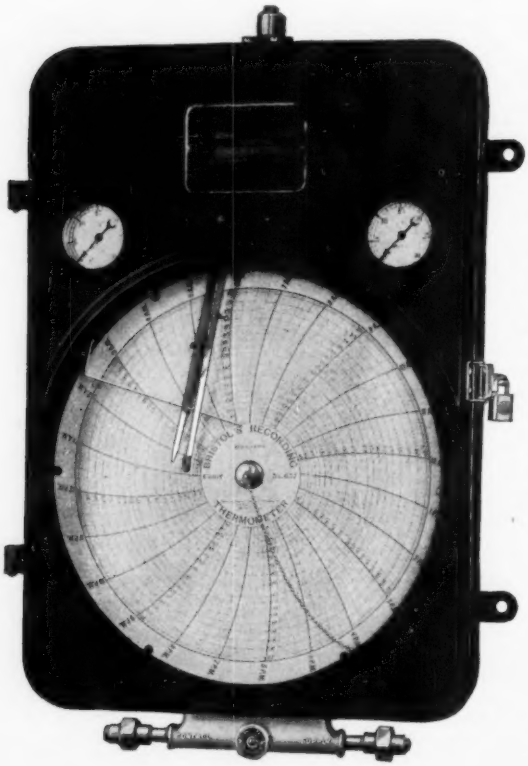
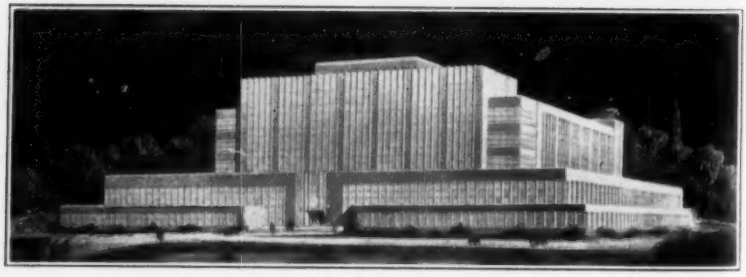


Fig. 2

The free vane recorder controller is enclosed in a two part cast aluminum case of moistureproof construction. It is furnished with inverted penarm and fountain pen as standard equipment. The chart is rotated by a powerful spring clock or Bristol's Telechron operated clock. The case is available for wall or flush mounting. Furnished as a single or two-pen instrument in combination of pressure or temperature and has a pressure range up to 1500 lbs./in.^{2} and temperature range up to 1000°F., using 12″ charts. Temperature measuring systems may be either vapor or gas filled depending on the operating temperatures encountered.

New Federal Forest Products Laboratory Building



The largest and most complete establishment in the world for research on wood will be constructed at Madison, Wis., under a Government contract just awarded. In the new building, equipped with modern scientific and technical facilities, the Forest Products Laboratory of the U. S. Forest Service will continue the work, initiated 21 years ago, to improve the production and broaden the uses of all classes of forest materials. C. B. Fritz & Company of Madison, Wis., were the successful bidders on the building project. Holabird and Root, Chicago, are the architects. Davidson and Constable, Stamford, Conn., assisted in the landscaping design.

Flush Type Graphic Instruments

(*Esterline-Angus Co.*)

A GRAPHIC meter, unlike most other switchboard equipment, must be serviced regularly, by the renewing of record charts and ink, and rewinding of spring clocks. This requires that a flush instrument be entirely accessible from the front. This new meter has been designed so as to require minimum switchboard space and at the same time give easy access to all the mechanism from the front of the case.

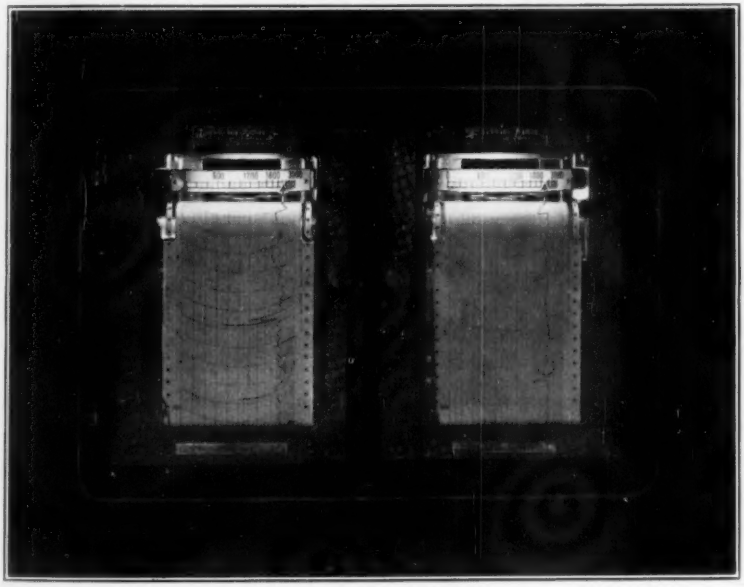
Flush instruments are furnished in both single and twin type cases. These are made o cast aluminum alloy, making them light and strong. The dimensions are as follows:

	Single	*Twin*
Height (over flange)	16¼"	16¼"
Height (panel opening)	14¾"	14¾"
Width (over flange)	12¼"	23"
Width (panel opening)	10¾"	21⅜"
Depth (panel line forward)	1⅜"	1⅜"
Depth (panel line backward including multiplier)	11"	11"
Depth (panel line backward, noti ncluding multiplier)	7⅜"	7⅜"

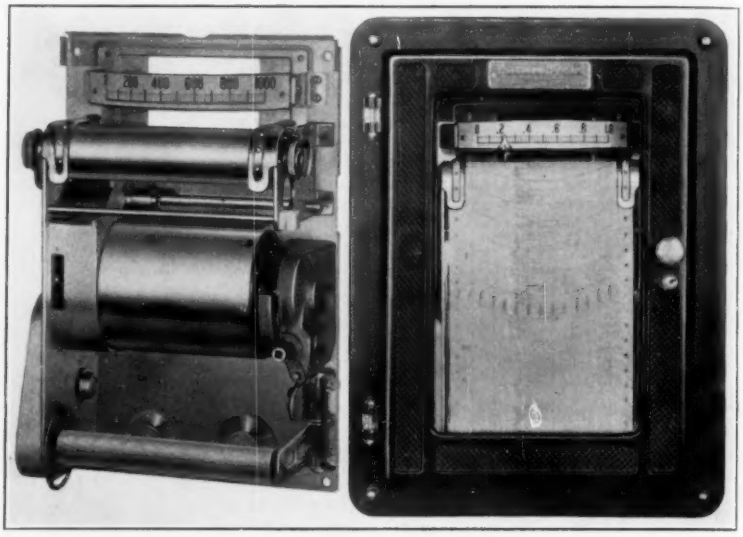
The case castings are carefully finished, filled and rubbed smooth and given two coats of dull black enamel baked until hard. The single instrument has a door fitted with a glass panel, and the twin has two doors. The doors are fitted with a soft rubber gasket, cemented in place, which makes them dust proof. The doors are fitted with automatic latch and pull and tubular locks. All case trim is heavily plated and polished.

The terminals for connecting to the instrument are mounted in bakelite mouldings, which extend through openings in the back of the case. The standard mounting for the multiplier is on the back of the instrument case, but where specified it can be furnished for separate mounting. All flush instruments are furnished with illuminated scales and charts.

Flush instruments can be furnished with either spring clock or telechron clock chart drive for chart speeds of ¾, 1½, 3, 6 and 12 inches per hour. When so ordered, and at a slight extra cost, either spring or telechron clocks can be furnished to give the above chart speeds per hour and the same chart speeds per minute. When desired, the standard Esterline



Night view of a twin flush meter on the switchboard of a large power plant. These two particular instruments make continuous records of the conductivity of the distillate and condensate in this plant. Other similar instruments record the kilowatts, voltage, power factor and frequency



In the flush instrument, the entire chart-driving mechanism is mounted permanently on an aluminum plate, which can be removed from the front by taking out four screws. These plates are absolutely interchangeable in all instruments, either single or twin types.

Front view of a single flush type instrument. Nine inches of the chart is visible. Space required is 12¼ x 16¼ inches. Projection in front of the board is only 1⅜ inches.

Angus "quick-trip" attachment can be applied to these instruments to give chart speeds in inches per second.

As shown in the accompanying illustrations, the chart-driving mechanism in these instruments is completely assembled on a flat aluminum plate, held in place by four screws. This plate rests on four milled bases in the corners of the case. By removing the four screws, the entire chart drive can be lifted out. Irrespective of the kind of chart drive used, these plates are interchangeable, so that one chart drive can be replaced by another, without disturbing the rest of the meter.

In order to produce a convenient flush instrument, it was necessary to make a clock which can be wound from the front instead of the side. In doing this, our designers have gone further by providing that all three springs are wound at one time, with a small crank. This adds both to safety and convenience.

When telechron clocks are furnished, the spring barrel and the escapement are omitted and a telechron motor clock is supplied. This and the chart drive roll are mounted on the interchangeable plates which have been described. A small hand-wound spring is used to drive the re-roll, as the telechron motor is unsuited to the variable load imposed by the re-rolling mechanism. Telechron motors can be furnished for either 110 or 220 volt operation, and for any commercial frequency.

The quick-trip attachment is a motor-driven device which can be attached to a standard instrument to give extremely high chart speeds. It is largely used on power circuits for studying disturbances, the purpose of the high chart speed being to open up the record during a disturbance. Under normal conditions, the chart moves at slow speed; when the disturbance occurs, the chart is speeded up instantly; as soon as the disturbance is over, the meter resets the chart to correct time, and resumes operation at normal chart speed. The quick-trip can be attached to either single or twin flush type meters.

All standard measuring elements comprising the Esterline-Angus line of graphic meters can be furnished in flush type cases, with the exception of the K. V. A. Meter.

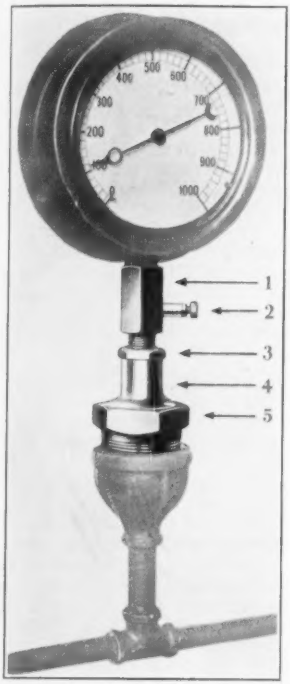
The complete list includes the following:

A. C. Ammeters	Frequency Meters	D. C. Milli-Ammeter
A. C. Voltmeters	Power Factor Meters	D. C. Voltmeters
A. C.—D. C. Voltmeters	Condenser Meters	Speed Recorders
A. C.—D. C. Wattmeters	Ohm Meters	Pressure Recorders
A. C. Wattmeters	D. C. Ammeters	Time Recorders

New Gage Protector

(*Champion & Barber*)

THE Champion gage protector is a simple, three part, bronze bodied, rubber bulbed pressure transmitting instrument, used to transmit line pressures to gage recordings by means of a secondary, or bulb pressure; said recordings being the result of the compression of said secondary bulb liquid by a given line liquid.



1. Main body of Non-Pulsator.
2. Needle Valve Adjustment Screw for Pulsator Control.
3. Packing and Lock Nut: Non-Pulsator to Protector.
4. "Neck" of Gage Protector.
5. Main body of Protector. Contains Pressure Bulb.

In construction the Champion gage protector consists of (1) the main body of the instrument, (2) the pressure transmitting bulb, and (3) the bulb retainer.

The body of the Champion gage protector is made of a special, non-corrosive bronze; a bronze that is highly resistant to acids and other fluids. It is accurately machined throughout and made to withstand severe service abuse.

The most vital, and, only working part, of the Champion gage protector is the glycerine (or castor oil) filled pressure transmitting bulb. This bulb is at all times in direct contact with the exterior line pressures and the interior bulb fluid pressures. Due to this fact, the rubber used in the manufacture of the bulb is specially treated for resistance to acids and other fluids. By actual test, these bulbs have been found to withstand acids over long periods of time without showing appreciable deterioration.

The Champion gage protector is a pressure transmitting instrument operating by means of the compression of the secondary bulb liquid (glycerine or castor oil) by the line liquid. That is, the rubber pressure bulb is so installed that the line pressure (either fluids, liquids or air) is at all times operating against its base. This pressure action in turn compresses the glycerine (or castor oil) filled bulb and causes it to exert the necessary recording pressure against the gage movement, this in turn causing the poundage registration.

The fit of the pressure bulb is so "snug" that at no time can line fluids or line solids pass by and enter the tube or movement of the gage in use. This fact alone is extremely important, for previous to the introduction of the Champion gage protector there were no gage accessories available that would keep the gage tube and movement absolutely free of solids.

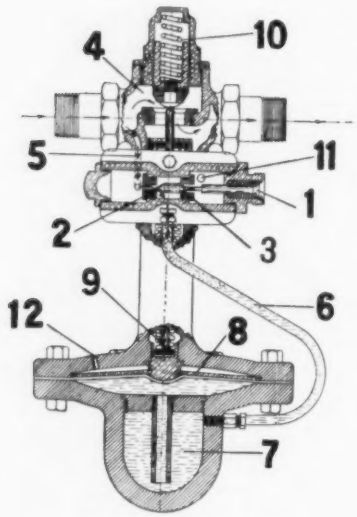
The adaptation of the Champion gage protector to an ordinary gage transposes this same gage into an all-purpose gage. This is possible because of the restriction of line liquids and solids from the gage tube and movement. This eliminates the use of special tubes, etc., for specific conditions.

New Temperature Regulator

(*Sarco Co.*)

THIS regulator is of the indirectly operated type, for intermittent service for pressures of 5 to 125 lbs., where the thermostat actuates a small pilot valve which admits the pressure to a large area diaphragm. This diaphragm, in turn, operates the main valve.

The main regulator valve is of the single seated, overbalanced type, held tightly to its seat, in the closed position, by a powerful spring. In operation, the main valve is either wide open, or closed tightly. The regulator, therefore, is especially well adapted for intermittent service where no additional heat is required over long periods, as for example in hot water service for wash rooms or showers; for adding live steam to the exhaust in feed water heaters, or similar



applications.

While this valve will not throttle, the regulator is very sensitive, since the thermostat merely opens and closes a small pilot valve, always of the same size, regardless of the size of the main valve. Very close control of temperature is the result.

Since the main valve is opened by line pressure and closed by a spring, the valve will close if the line pressure should fall below the required minimum operating pressure of 5 lbs., thus protecting the thermostat against overheating.

The stem of the main valve is packless, being sealed by a Sarco seamless corrugated bellows. There are no stuffing boxes to leak or stick.

The seats, both of the pilot and of the main valves, are made of hard nickel alloy and renewable. The disc of the main valve is asbestos composition and also renewable.

OPERATION

Assuming a standard Sarco thermostat as for TR-21 attached at "1" and inserted in the apparatus to be controlled, and assuming that the temperature of the medium is below that for which the thermostat is set,—then pilot valve "2" will be open and exhaust valve "3" will be closed.

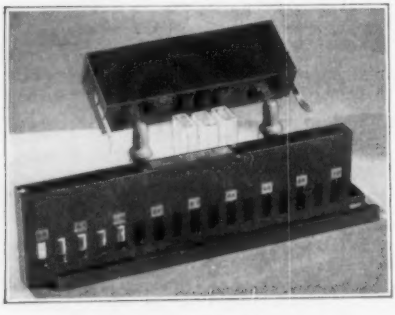
Steam (or other heating medium) entering the main valve "4" in the direction of the arrows, passes through port "5", valve "2," tube "6" into diaphragm chamber "7," thus raising diaphragm "8." Valve stem "9" is thus pushed up, opening main valve "4" and compressing spring "10." When the desired temperature is reached, the thermostat closes pilot valve "2" and opens the exhaust port "3."

The pressure under diaphragm "8" is then exhausted through tube "6," exhaust valve "3" and exhaust port "11" to atmosphere or a drain line not under pressure. Spring "10" then pushes the main valve "4" closed, and steam pressure, being on top of disc, holds it closed.

As soon as the controlled apparatus requires further heat, the thermostat will reopen pilot valve "2" and another cycle of operation will begin.

The chamber "7" with its tube connecting to the diaphragm chamber, furnishes a reservoir which assures that only cool water can come in contact with diaphragm "8." A small vent hole "12" relieves air and maintains atmospheric pressure on top of diaphragm "8."

New Chlorine Comparators



Enslow Slide Chlorimeter

W. A. Taylor & Co. has developed the Enslow slide chlorimeter, Taylor swimming pool set, combination swimming pool set, and chlorine slide colorimeter, for control of chlorine and pH in water, sewage, industrial wastes, swimming pools, sterilizing and bleaching solutions, etc. All this equipment is molded from Bakelite and works on the slide principle, thus combining durability, precision, convenience, and simplicity.

All these sets are similar in construction and method of operation. Each consists of 2 principal parts—the slide and the base, as shown in the illustration. The slide is a Bakelite case 10 x 2.75 x 6.25 inches. It contains 9 color standards representing different amounts of chlorine or pH values, and 8 ampoules of distilled

water, the ampoules of water alternating with the color standards. The lower part of the base contains a slot in which the slide may be moved back and forth, 2 holes containing vials of ortho tolidine or phenol red solution, or both, and 3 holes containing molded Pyrex cells 89 x 25 x 11 mm. The upper half of the base serves as a cover for the vials and cells when the set is not in use and is fastened to the lower part by means of spring catches.

The Enslow slide chlorimeter contains 9 chlorine standards representing 0.0, 0.1, 0.15, 0.2, 0.3, 0.4, 0.6, 0.8, 1.0 p.p.m. of chlorine. A determination consists in only 3 simple operations: (1) The 3 cells are filled to the mark (11.5 cc.) with the sample to be tested and placed in the 3 holes in the base. (2) To the central cell 0.5 cc. of ortho tolidine solution is added and the contents thoroughly mixed. (3) The slide containing the chlorine standards is placed in position on the base and is moved back and forth in front of the test samples until a color match is obtained. The chlorine content is then read directly from the values on the front of the slide.

The Taylor swimming pool set is similar in all respects to the Enslow Slide Chlorimeter except that the slide is divided into 2 sections. The left section contains 5 phenol red color standards (6.8, 7.2, 7.6, 8.0, 8.4) for pH determinations, and the right section 4 chlorine standards (0.0, 0.2, 0.5, 0.8, p.p.m.) for chlorine determinations. The base contains 1 vial each of ortho tolidine and phenol red solution.

The combination swimming pool set consists of one complete Enslow slide chlorimeter and an additional slide containing 9 phenol red color standards (pH 6.8, 7.0, 7.2, 7.4, 7.6, 7.8, 8.0, 8.2, 8.4). This set allows more precise control of both chlorine and pH than is obtained with the single slide set.

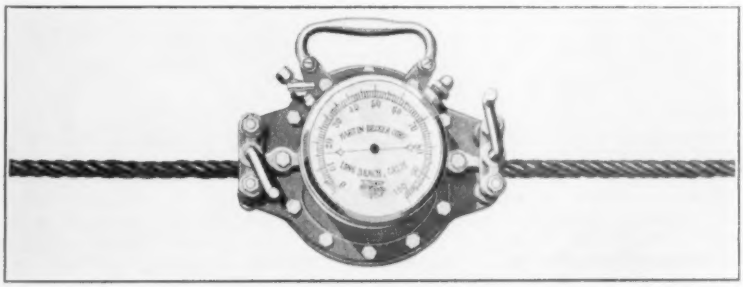
The chlorine slide colorimeter is similar to the Enslow slide chlorimeter except that 5 cc. test tubes are used instead of the molded Pyrex cells and that the slide contains standards representing 5, 15, 25, 50, 75, 100, 150, 200, 250 p.p.m. of chlorine. By dilution the chlorine content of solutions containing 4-5% available chlorine and 1-2% free caustic can be determined with an accuracy sufficient for all practical purposes.

Each of these sets is supplied in a polished wooden case 11 x 3.75 x 4.75 inches, with a handle for carrying. The case serves not only to keep all the equipment together in portable form but also to protect the sets from dust and dirt when not in use.

Tension Indicator

(*Martin-Decker Corp.*)

AN instrument that is proving of exceptional value for use wherever wire cables are used is the tension indicator shown in the accompanying illustration. It is clamped directly to the cable span, measuring the load by the deflection principle without dead-ending or taking up slack. The instrument is shown in two sizes; the Standard model will measure the load on any wire line between ¼" and ¾" in diameter up to 16,000 lbs. The Heavy Duty Model from ¾" to 2⅜" diameter up to 260,000 lbs. A definite off-set is made in the line between the two fixed points and the force required to make or maintain this off-set is shown on the gage—a direct indication of the line load. It may be applied to the line while already under load, prior to the application of stress, or during changes of the load and will accurately register the tension in the line at all times. By the use of a calibrated line, any pulling load may be measured.



The principle of the instrument's operation is as follows: At either end of the instrument adjustable clamps bring the line to a fixed stop. Between those clamps the line is off-set by a projection carried by a pressure plate. This pressure plate bears against a flexible, canvas-reinforced rubber diaphragm backed up by a body of fluid. The fluid pressure generated is a

positive measure of the force required to maintain this off-set and is indicated on the gage. It may be directly transposed into actual pounds tension on the cable.

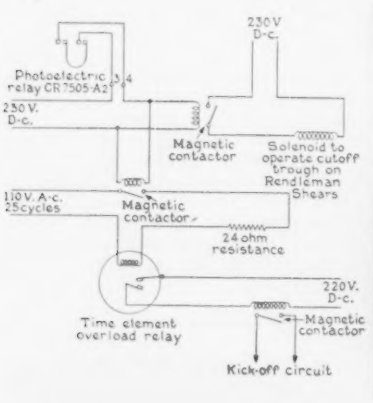
A particular advantage is that no special set-up is needed for testing. The cable may be tested while in actual use.

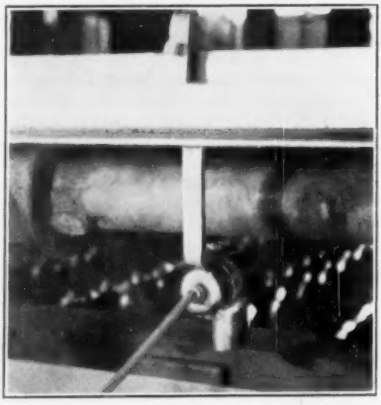
It is used for determining the loads on transmission lines, guy lines, cable messengers and for testing the holding power of various soils with various types of anchors and dead-men. It is also used for obtaining line loads on shovels, cranes, buckets, elevators, guy lines, derricks, —in fact on any wire line where actual measurement of the load is desired.

The "Standard" model is a smaller edition of the "Weight Indicator," an instrument which has been universally used for years to measure the loads on drilling lines in the oil industry. It weighs but 11½ pounds, complete, ready for operation. The gage is of sturdy construction and there are no delicate parts in the instrument to get out of order or require attention. Adjustment for temperature is easily made where close accuracy is required. The tension indicator is ruggedly built and has no delicate parts so that it is well adapted for field use. It may be applied to a cable, the load read and the instrument removed, all in less than a minute's time.

Photo-Electric Relay Operates Shear for Cutting Hot Bars in Rolling Mill

ONE of the new uses of the photo-electric relay is to be found at the Lebanon Plant of the Bethlehem Steel Company, Lebanon, Pennsylvania. Here the device is used in the process of cutting hot bars to hot bed lengths of approximately 150 feet as the bar passes from the last stand of rolls to the hot bed. The desirable features of this device as contrasted with the mechanical flag switch, are that it is more readily adjustable along the hot run-out conveyor to obtain accurate lengths of bars sheared for the hot bed; and that the time element between the arrival of the bar at the photo-electric tube and the operation of the Rendleman shear is more constant than in the case of the mechanical flag.





The use of an adjustable time relay was first considered, to provide intermediate rod lengths, but as it was necessary to provide for lengths increasing by increments of six inches, and as the rod travels at a maximum speed of 1,200 feet per minute, this meant a relay with a minimum time of 1/40 second and adjustable in similar increments.

By the use of the General Electric photo-electric relay it was found the equipment could be made to operate satisfactorily. When the front end of the hot bar passes beneath the photo-electric tube, there is enough light emitted from the bar to increase the current flowing through the tube and thus actuate the relay. The photo tube is mounted above the run-out table at any predetermined point suitable for causing a cut of the proper length, and is easily movable along the table to provide for different lengths.

The change in current in the photo-electric tube is amplified by a Pliotron tube mounted in the relay box some distance away. The amplified current energizes a sensitive relay in the box which causes two magnetic contactors to close. One of these operates the solenoid which throws the trough of the Rendleman flying shears and cuts the bar to the length desired.

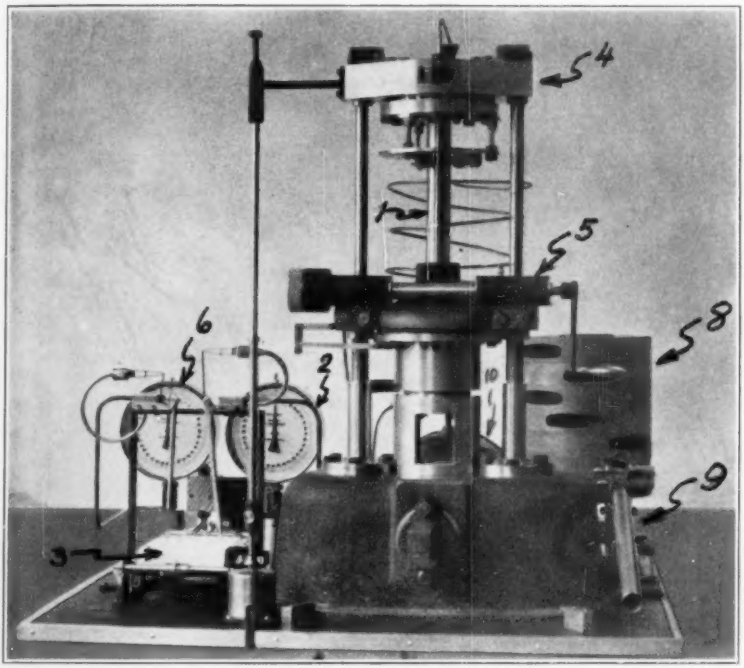
The other contactor energizes the A.C. coil of an induction type time element overload relay. After a predetermined time, which may be adjusted to suit the requirements, the induction type overload relay closes a 220 volt D.C. circuit which operates another magnetic contactor. This contactor controls the circuit to the magnetic clutch which engages the kick-off motor. Limit switches on the kick-off mechanism start the bed rocking mechanism, stop the kick-off mechanism after it has completed the cycle and provide interlocks as heretofore. The object of the induction type overload relay is to provide the necessary interval of time between the shearing and kick-off to allow the bar to reach the proper position in the hot run-out trough before being ejected upon the bed.

New Sheet Metal Tester

(Baldwin-Southwark Corp.)

THE Wazau sheet metal tester is a deep drawing press for drawing cups from circular sheet blanks. The male die (1 in Fig. 1) of 30 mm. diameter, is motor driven and the drawing force exerted by it is measured by a hydraulic capsule, indicating the load on dial 2.

There are two ranges of sensitivity of 10,000 and 20,000 lbs. for the standard type of the tester, which is built in higher capacities, if desired. On the paper strips 3, a record is made of drawing force. The die 1 is attached to the upper crosshead 4, which is driven by a reversible motor, 10.



The deep drawing speed normally amounts to about 4" per minute, but can be adjusted to other values on request.

The middle crosshead 5 carries the hold-down or blankholder, which is adjusted by hand, because it has to make small movements only. It is of particular advantage that in the Wazau sheet metal tester the pressure of the blankholder can be varied at will and measured, while in normal testers, no check of the blank holder force is possible. The blank holder loads are indicated on dial 6 and recorded on paper strip 3. Both the drawing and the hold-down force are recorded in function of the depth of draw. In this way all important variables can easily be studied and the records leave no doubt whatsoever.

The hold-down pressure is not only indicated and recorded, but can be maintained at any definite value desired, by means of a special load maintainer. This device consists of a dead weight accumulator 8 and hand pump 9. The innovation is important in that all uncertainties of tight or loose fitting of the hold-down are eliminated and the trend in practical drawing is closely imitated.

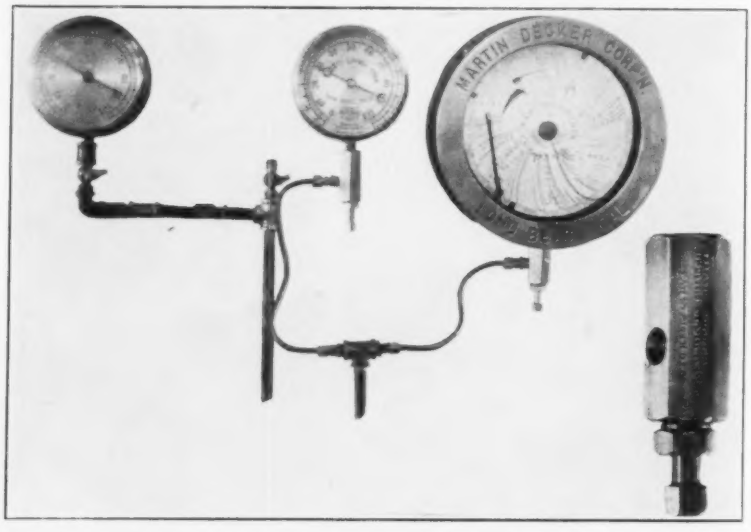
It is advisable to qualify sheets by arbitrarily selecting a certain blank diameter and drawing cups with different blank holder loads. Two things may then happen: first, failure occurs at a certain blank holder load, which thus forms a criterion, together with the initial blank diameter. If, two sheets show the same qualities in this way, there may still be a difference in drawing forces permitting clear differentiation. The second case occurs when the sheet does not fail even at the highest blank holder load available. The high drawing capacity indicated hereby may then be tested by using a larger initial blank diameter and repeating the first method of test until failure occurs.

The entire procedure is autographically recorded in every step and in addition to such data as depth of draw, blank holder and drawing force, the inspection of the cups drawn furnishes useful information.

The tester can also be used to determine the best lubricant as well as radii of fillets, clearances, and so forth, in other words those factors involved in the drawing process not depending on the material itself but on the design of the drawing machine.

Pulsation Dampener

THE Martin-Decker Coporation has produced the adjustable dampening unit known as the "Utility" Model Pulsation Dampener which is adapted for throttling the pulsations of gages and recorders on compressors, pumps and pressure operated devices of all types. This device may be used either for a few inches of water or for several thousand pounds gage pressure in liquids or gases. While dampening out pulsations, whether slow or rapid, there is no appreciable time lag. It is sensitive to either large or small changes in pressure and the gage indicates the true mean pressure. It may be cleaned, if necessary, without disturbing the connections. It is not a needle valve, nor does it operte on the needle valve principle.



The accompanying illustration shows a gage and recorder fitted with this device connected in parallel with an unprotected gage on a compressor line. The recorder shown is fitted with a half-hour clock, so that each quarter hour division represents eighteen and three-quarter seconds. The response of the recorder to pressure changes from maximum to zero can be observed.

It is adaptable to low pressure manometers, U-tubes, and draft gages, orifice meters and many other types of pressure instruments.

It is manufactured in two models: the "Regular" with brass body and stainless steel stem for usual installations; and the "All Stainless" for use under high temperatures, extremely high pressures and other installations where brass would not be adaptable.

New Cathode-Ray Oscilloscope

(*Westinghouse Elec. & Mfg. Co.*)

ORIGINALLY developed for television, the latest Westinghouse cathode-ray oscilloscope places in the hands of engineers a portable, high speed instrument, free from moving parts and especially suitable for visualizing periodic electrical phenomena. It easily catches events lasting but a millionth of a second. The curve traced on the oscilloscope's screen is brilliant enough to be seen in daylight, making the device of considerable importance in lecture rooms for demonstrating such difficult problems as the effect of circuits on wave form. A special multivibrator circuit gives linear timing when wanted; but this new instrument, unlike the ordinary oscillograph, is not tied down to "time" as abscissa—it accurately plots any two variables against each other.

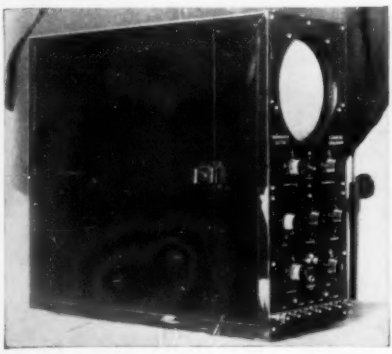


Fig. 1. The New Cathode-Ray Oscilloscope.

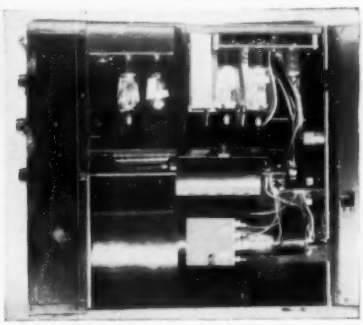


Fig. 2. Interior View Showing Location of Parts.

Briefly, the oscilloscope, looking like a big bottle, is a large vacuum tube with a hot filament "cathode ray gun" at one end and a 7-inch diameter fluorescent screen at the other—the bottle's bottom. Anodes surrounding the filament focus the cathode ray on the screen, which glows bright-green in the spot where the ray touches it. The ray can be moved up-and-down or sidewise (the bottle being horizontal) by controlling coils or plates at the sides of the bottle. The ray is thus an inertialess pointer which traces a curve, the coordinates being any two variables that may be put on the control coils or plates. The ray may trace the curve in a few millionths of a second but the fluorescence lasts long enough for the eye to catch it.

Like astronomers who predict the existence of a new planet long before telescopes are able to see it but are finally corroborated by the improvements in instruments, the "cathode-ray bottle" finally enabled Dr. Slepian to demonstrate visually his basically new theory of what happens when an arc is extinguished.

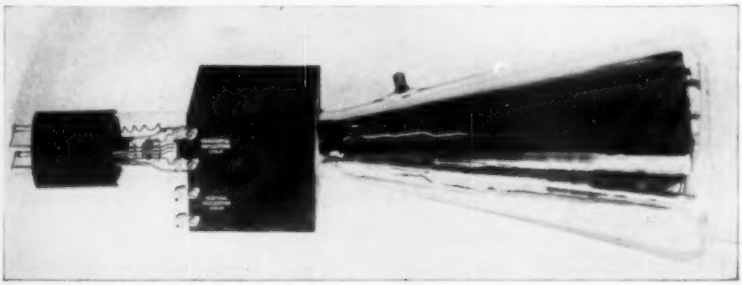


Fig. 3. The Cathode Ray Tube with Deflecting Coils in Place.

In striking contrast to its obvious possibilities in universities and research laboratories, the oscilloscope is used as a production shop test for the new porous block Autovalve lightning arrester. Each block gets an individual test—the tester touches the switch of a 50,000-volt surge set which supplies the lightning stroke and sees before him, on the oscilloscope screen, the exact performance curve. Such actual shop test, or commercial demonstration, of arresters has never before been practical.

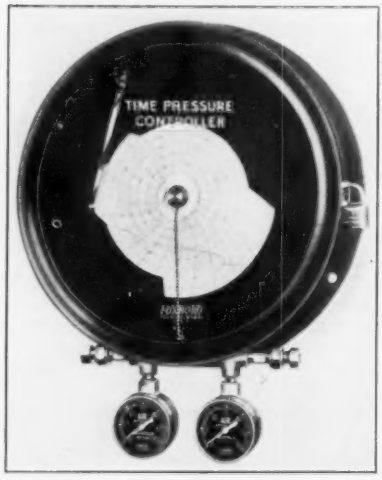
The new oscilloscope can simultaneously show 2 separate waves in their true phase relation, by using a simple synchronous distributor which rapidly switches the input terminals of the instrument from one wave to the other. Sustained vocal sounds, musical instruments, even noisy machinery, can be studied by the device.

This oscilloscope will not replace the usual oscillograph in the proper field of the latter, but will undoubtedly open up a new field of its own—perhaps allow shop testing of apparatus.

Non-Recording Time Controller

(*The Foxboro Company*)

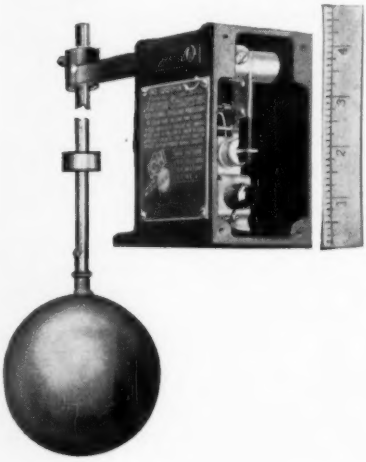
THIS is a new instrument for controlling temperature or pressure in relation to time. This instrument, known as the Non-Recording Time Controller, will maintain a predetermined cycle of operation in any process involving temperature or pressure. The instrument is similar in appearance and construction to the standard Foxboro recorder-controller. The major difference between the two instruments is that the non-recorder has a printed aluminum cam instead of a paper chart and a specially designed cam follower in place of the pen arm. This unique construction has made it possible to obtain a 1 to 1 ratio between the cam reading and control point setting, thus maintaining the control point without the use of multiplying devices of any kind. The cam is a printed aluminum disc the size of a standard Foxboro 10″ chart. The markings are printed by a special process from plates similar to those used in the printing of Humitex charts. This feature makes the use of the instrument particularly flexible since new cams to meet changed conditions can easily be cut by the user with a pair of shears and a file. The controller is designed for use on industrial processes in which the relation of time to temperature or pressure is important. One of the most interesting and successful applications of this instrument is the maintenance of gas pressures in lines where the load requirements are predetermined. In this application, the controller is used in conjunction with a diaphragm-motor lever and controlled valve, to build up or let down the pressure in the line according to previously determined load conditions.



New Float Operated Motor Starter

(*Cutler-Hammer, Inc.*)

FOR small A.C. and D.C. motors on cellar drains, sump pumps, open tanks and similar application, the new float operated motor starting switch provides across-the-line starting, thermal overload protection, and is small in size. For larger motors, this same device can be provided without overload protection so it can be used as a master switch in the control circuit of a separate automatic starter. It can also be furnished without the float accessories



for use as a lever operated master switch.

This is a single pole starter with double break, silver contacts to assure continuous current carrying capacity. Contact mechanism is quick make and break. The operating lever and shaft are reversible in the case and the operating lever can be shifted to any angular position of the shaft, so either tank or sump operation can be obtained with the starter mounted in any position.

The thermal overload relay protects the motor from burnout and prevents unnecessary blowing of fuses. It is free tripping, the switch cannot be held closed on an overload. When the overload trips, it is necessary for someone to go to the switch and return the operating lever to the full "off" position to reset the overload. This means the operator will also check the cause of the overload and clear the trouble before restarting the motor.

Maximum ratings for this float operated motor starter are A.C., ½ HP, 110 or 220 volts, single phase; D.C., ⅙ HP, 115 volts.

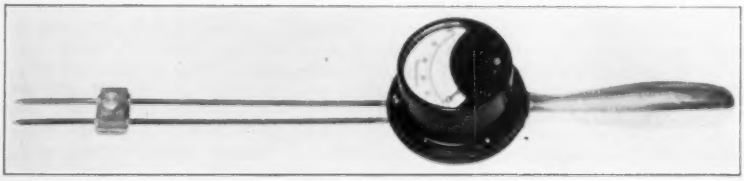
New Type Contact Pyrometer

THE Illinois Testing Laboratories, Inc. has recently developed a new type contact pyrometer for detecting hot bearings on locomotive rolling stock and other purposes.

It consists of a highly sensitive yet rugged millivoltmeter to which is attached a pair of pointed thermo-couple wires. To take a temperature reading it is merely necessary to press the points of the thermo-couple wires against the bearing or metal surface as this completes the circuit.

Almost instant readings are obtained for the moment contact is made with the heated metal surface, the pointer needle of the indicator responds.

This pyrometer is furnished in several different temperature ranges—the lowest range 0°-600°F. and is, therefore, the one most generally used for bearings. The instrument can be furnished with an internal automatic cold end compensator to take care of atmospheric temperature changes when used out of doors.



It is reported that a number of railroads are using the pyrometer for journal bearing temperatures of locomotives. Most generally these are used by terminal inspectors to check the bearing temperatures as the engine comes in off the run to detect any hot bearings, permitting the conditions to be remedied before serious damage results.

A larger and heavier model of similar design is available for measuring surface temperatures of rail ends in the building up process and subsequent heat-treatment.

This instrument is recommended for temperatures to 1500°F. It is especially suited for brass, aluminum and zinc billets, bars, and for certain forms of iron and steel where the surface is not too hard and which is free from scale.

Measurement of Velocity and Direction of Water Currents

*Rene Leonhardt**

THE investigation of marine and tidal currents by means of current measurements is one of the most useful processes in the realm of oceanography and hydrography. These studies are not only of great value from the purely scientific standpoint, but they furnish indications that are often extremely useful in practical navigation as well as in harbor and waterways construction, and in river and deep-sea fishery.

The accurate measurement of the currents is of especial importance for the determination of the periodic and aperiodic movements of the water in tidal seas. The tidal current, being the horizontal component of the tidal phenomenon, is as yet easier to determine on the high seas than is the rise in the water-level due to tidal action, and therefore these measurements furnish indications that are essential alike to practical navigators and to scientific investigators, the latter, in particular, being thereby enabled to carry forward their studies into the complex subject of tidal action.

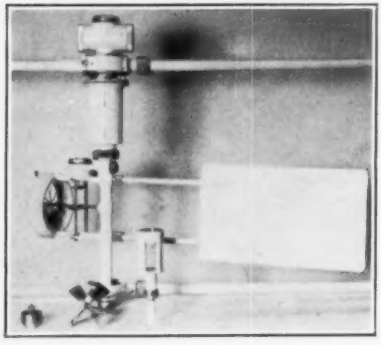


Fig. 1

When making measurements in smooth and shallow water, as for instance in river estuaries, it is not difficult for a ship to be moored by four or six anchors with the assistance of a tug. At moderate depths the ship can be further secured in position by the use of an additional anchor at the bow and one dropped from the stern; where however the depth exceeds a couple of hundred fathoms, this process is not only very laborious and tedious, but is liable to involve the loss of the anchoring gear in a storm.

It follows from the foregoing that the ship should preferably be made fast to a single anchor, but that the current measuring apparatus and the method of observation should be so desgined that errors due to yawing and swinging of the vessel can be eliminated from the final reading. This can be done mathematically by tacking observations at short intervals extending over one or more periods of yawing and swinging, so that vectorial averages covering those periods can be found.

To establish the direction with accuracy, there must be a standard direction on the current-meter for every angle reading. The known forms of apparatus to determine the speed and direction of currents divide themselves into 2 distinct groups according to the manner in which they provide this standard direction. The first group comprises all those instruments in which a magnetic needle is the means for indicating or recording the direction of the current. In every such instance the compass needle moves over a card which is connected with the vane that responds to the direction of the current, the card therefore adjusting itself automatically in relation to the needle according to the direction in which the current flows. In the apparatus of the second group, the standard direction is obtained by having the zero position of the current meter in a fixed and definite relation to the hull of the ship, i. e. to the ship's apparent course, this being achieved by a method of two-line suspension.

In the current meters embodying a compass, the compass needle will point to the magnetic North so long as it is subject only to the action of the earth's magnetic field. When, however, work is done with a meter of this type from a steel ship, a second magnetic field set up by the magnetism of the ship also acts on the compass needle, the so-called local attraction, which falsifies the readings of the compass.

In shallow waters and on certain ships' courses the error due to local attraction may be as great as 180° so that it becomes impossible to determine with any accuracy the direction of the current to be measured.

The high cost of exploratory voyages with big ships on the high seas, coupled with the fact that the measurements of currents thereby obtained are not altogether reliable, would seem to make the use of current meters of this design no longer justifiable. In the German Marine Observatory at Hamburg, a two-line suspension current meter containing no compass

*Askaniawerke

in the instrument itself, whereby reliable readings can be obtained, has recently been developed.

The essential parts which go to make up the complete equipment of the new current-measuring gear, are:

1. The actual current meter with switchgear, spindle, current vane, propeller, contact box, and bottom contact and frame (Fig. 1).
2. The recording apparatus (Fig. 2).

The current meter is secured within its frame in such manner that it is free rotate on a vertical spindle. This spindle carries 2 welded projections by means of which it supports on one side a protecting ring within which a multi-bladed propeller is free to revolve, and on the opposite side the vane, the function of which is to keep the propeller turned so that it faces the current.

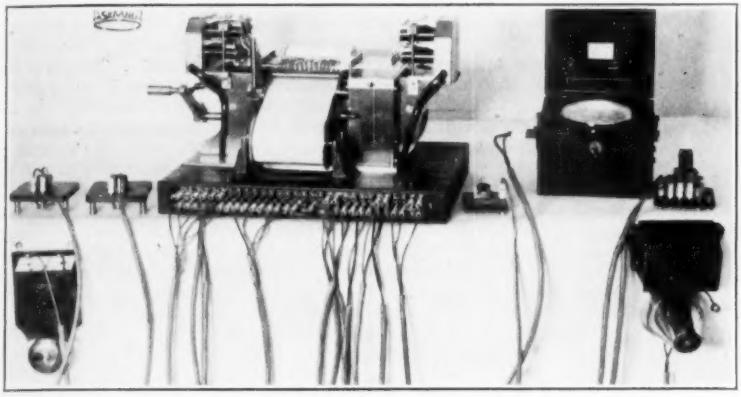


Fig. 2

The current will, according to its strength, cause the propeller to revolve more or less rapidly. The velocity of the current can be deduced from the number of revolutions made by the propeller within a given unit of time.

When the apparatus is in action the revolutions of the propeller are transferred by means of worm gear to a contact disc located in the small contact box in front of the spindle of the instrument, which is connected by cable to the recording instrument kept on board.

The direction of the current in relation to the frame of the instrument, or to the head of the instrument which is secured so as to prevent it from revolving, is measured by means of the switchgear in the interior of the current meter casing. Twelve contact levers, insulated from one another but permanently connected to the head of the meter, brush against 12 cam discs connected with one another by conducting material and rotating in unison with the spindle of the current meter. These 12 cam discs fall into 3 groups. The angle formed by the longitudinal position of the frame and the direction of the current or of the vane must be somewhere between 0° and 360°. When the scale is tried, to find the angle, contact between one of the four cam discs in the first group and the contact lever opposite it will first tell us within which quadrant the required angle is situated. At the same time, contact between one of the levers and one of the 3 cam discs in the second group will show within which third of that quadrant the angle is to be found. Finally, contact levers touching 1 or 2 of the 5 cam discs in the third group will show in which tenth of that third the required angle is located. Every time the angle between the direction of the frame and that of the current alters to the extent of 3°, the contacts between levers and cam discs will be different and will be distinctly recognisable.

From the individually insulated contact levers and also from the contact box to which the revolutions of the propeller are transmitted, connecting wires lead to the head of the meter, which carries 2 cable connection. At these points 2 seven-core cables are fixed by water-tight connections. About 3 meters from the lower extremities of the cables 2 supporting ropes are firmly secured to the cable covering, and by these ropes the instrument frame is suspended.

The 2 cables pass over 2 light guide pulleys on the end of 2 booms carried on board the observation vessel and reach the winches placed on board, each of which is designed to carry 30 fathoms of cable. By means of these winches the current meter in its frame can be lowered to any desired depth.

Each cable is connected to the winch in such manner that the electric current passing through each core of the cable can be picked up separately by means of sliding contacts and transmitted, for instance by means of seven-core rubber-insulated leads, to the recording chronograph.

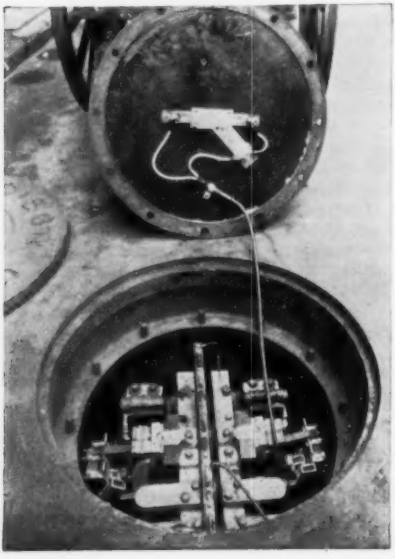
This recorder uses chart paper 110 mm. in width which moves forward by clockwork at the rate of 30 mm. per minute. It is provided with 14 pens, with 14 corresponding electro-magnets which actuate them each time the respective circuits are closed. The first of these magnets receives each minute a sharp surge of current, through a relay to the primary circuit of which a ship's chronometer making contact once a minute is connected. The first of the 14 pens accordingly traces an accurate time record on the chart. The second magnet actuates the second pen, which records the number of revolutions of the propeller. The remaining 12 pens serve to record the direction of the current. These also are actuated by electro-magnets connected by leads to the contact levers of the cam discs in the switchgear. Every 10 seconds or every 5 seconds a current is sent through the instrument, this being so arranged that the current actuates different electro-magnets according to the position of the current vane at the moment, and the corresponding pens draw points on the chart. These pens are filled with different colored inks—red and blue—according to their groups, so that a glance at the chart will tell the observer at once which of the contact levers in the several groups are making contact for the time being with the cam-discs in the body of the current meter, and by that he can measure the angle between the frame of the current meter and the current.

Assuming that the suspension points of the 2 cable pulleys are in a line exactly parallel to the ship's axis, the direction of the current will be evident from the angle indicated by the recording instrument, taken in conjunction with the ship's course as shown on the ship's compass. The angle can be determined with an error of not more than 1.5° at each reading.

With all this, current directions can be recorded 6 or 16 times within a minute with an accuracy of about 1.5° for each individual reading while the accuracy of the velocity readings lies within a few mm. per second.

Space Heater Protects Control Apparatus

(Westinghouse Electric & Mfg. Co.)



MUCH of the trouble due to moisture condensing and dripping on control apparatus installed in manholes has been eliminated by the use of electric heaters.

The illustration shows a typical installation for a manhole breaker. The small Westinghouse electric space heater, rated 220 watts, is attached to the cover and is protected against burnouts due to overheating and the temperature of the cover is controlled by the Westinghouse "Built-in-Watchman" thermostat. By keeping the temperature of the cover approximately 100°F. moisture will seldom condense. The photograph shows clearly the method of mounting the electric space heater and thermostat.

The thermostat is one of the Westnghouse "Built-in-Watchman" thermostats with practically indefinite contact life and is quick make and break and non-radio interfering. In addition to limiting the temperature of the cover the thermostat protects the space heater against over-heating. The thermostat is applicable for voltages of 110 and 220 volts AC and 115 volts DC.

CATALOGUE LIBRARY

Check the publications you want. Remove the page and send with coupon to INSTRUMENTS. They will be forwarded to you without obligation.

SEND COUPON FOR LITERATURE DESIRED

INSTRUMENTS PUBLISHING CO., 3619 Forbes St., Pittsburgh, Pa.

Please send us, without obligation, the literature checked herewith.

Company _____

Name _____

Address _____

Title _____

GRAPHIC INSTRUMENTS. A list of 42 publications on specific uses of graphic instruments. Esterline-Angus Co. Indianapolis, Ind.

PARKS' PARABLES. "When it Rains, Is Your Production Up" is the feature of the September, 1931 issue of this publication. Parks-Cramer Co. Fitchburg, Mass.

DENSITY METER. Bulletin No. 442 describes an indicator and recorder of density of smoke or dust emitted by boiler furnaces. Frank Sawford, Vancouver, Canada.

STEAM TRAP. Bulletin No. 1015 describes a new thermostatic steam trap. C. J. Tagliabue Mfg. Co., Park and Nostrand Ave., Brooklyn, N. Y.

TIME SWITCH. An 8 page booklet describing and illustrating automatic time switches General Electric Co., Schenectady, N. Y.

PLASTIC PRODUCTS. Several pamphlets issued by the Plastics Department, General Electric Co., Schenectady, N. Y.

CURRENT TEST SET. Bulletin No. 180 describes a split-core test set which is used for measuring alternating currents without interrupting service. Rubicon Company, 29 North Sixth St., Philadelphia, Pa.

CONTROL TEMPERATURES RELIABLY. Three circulars identified by the titles "Better Chemical Products" "Better Glass Products" "Better Gas." Leeds & Northrup Co. 4901 Stenton Ave., Philadelphia, Pa.

LENSES. Pocket size Catalogue No. 31 entitled Photographic Lenses & Shutters. Wollensak Optical Co. Rochester, N. Y.

GAUGE PROTECTION. A circular describing a gage seal and a gage non-pulsator. Champion & Barber 576 Subway Terminal Bldg. Los Angeles, Calif.

BLANCOMETER. A booklet describing the Blancometer used for specifying nearly-white colours. Applicable to papers, fabrics, paints, powders and other raw materials and products of industry. Adam Hilger, Ltd. 24 Rochester Pl. Camden Rd. London N. W. 1, England.

BLOWERS. Bulletins 22-B-10 and 23-B-10 describe standard duty blowers used in aeration of liquids, burner service, ceramics, chemical processes etc. Bulletins 32-B-10 and 33-B-10 describe standard duty gas pumps. Roots-Connersville-Wilbraham, Connersville, Ind.

TUBING AND THERMOMETER INSERTERS. Bulletin No. 468 describes the Loucks Tubing Inserter used for preventing injuries when inserting tubes, thermometers, etc. into rubber stoppers. Eimer & Amend. Third Ave. 18th to 19th St., New York.

RESISTANCE TESTERS. 20-page Catalogue 1290 describes and illustrates "Bridge-Meg" and Varley Loop "Bridge-Meg" resistance testers. James G. Biddle Co. 1211 Arch St., Philadelphia, Pa.

GRAPHIC INSTRUMENTS. No. 931 of The Graphic describes a flush type graphic instrument adapted to conform with general practice in switchboard building. Esterline-Angus Co. Indianapolis, Ind.

MICROSCOPES. A leaflet describing a single inclinocular used for observation and efficiency. B. K. Elliott Co. 126 Sixth St., Pittsburgh, Pa.

AIR CONDITIONING. A small booklet entitled, "Conditioning the Air for Health and Comfort." The Lewis Corporation, 829 Second Avenue, South, Minneapolis, Minn.

THERMOMETER BRIDGE. Circular 8063-G describes a semi-precision thermometer bridge for measuring resistances from 0 to 200.1 ohms. Leeds & Northrup Co. 4901 Stenton Ave., Philadelphia, Pa.

WATER WORKS JOURNAL. The August 1931 issue of this publication contains the following feature articles: "Cincinnati Water Works Billing Procedure," "History of the Fort Dodge City Water Works," "Science in Industry" etc. Pittsburgh Equitable Meter Co. 400 Lexington Ave., Pittsburgh, Pa.

LABORATORY APPARATUS. A 60-page catalogue identified as List No. 96 devoted to apparatus for testing petroleum, tar, asphalt and their products. A. Gallenkamp & Co. Ltd. 17 Sun St. Finsbury Sq., London, E. C. 2, England.

HEAVY DUTY MOTORS. A four page leaflet No. 20525 describes a new mill motor which embodies the latest recommendations of the Association of Iron and Steel Electrical Engineers. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

GAS SERVICE JOURNAL. The August 1931 issue of this publication features the following articles: "Classification of Continuous Flow Gas and Liquid Meters"; "The Ignition Velocity of Gas Mixtures" etc. Pittsburgh Equitable Meter Co. 400 Lexington Ave., Pittsburgh, Pa.

RADIO EXPERIMENTER. Vol. VI. No. 3 of this publication contains the article "Speeding up the Standard-Signal Generator." General Radio Co. 30 State St., Cambridge A, Mass.

COMBUSTION CONTROL. A circular entitled Metered Combustion Control. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

NEW TAG GENERAL CATALOGUE. This general Catalogue, consisting of more than 100 pages, now places under one cover the complete line of TAG Controllers, Recorders, Dials, Thermometers, Hydrometers, Oil Testing Instruments and Moisture Meters. Appropriate classifications of the many groups of instruments have been carefully considered and there are many applications of these instruments described and listed. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

WATER METERS. 38-page Bulletin No. 600 describes instruments for measuring water and other liquids. Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill.

OIL CIRCUIT BREAKERS. Circular 1921 covering types GO, GO-1, and GO-2 oil circuit breakers, a line of low-capacity outdoor breakers for use in distribution or low-voltage transmission systems. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

THE FOG HORN. The August, 1931 issue of this publication features part two of the article entitled "Defects in Rayon Goods" by H. R. Mauersberger. Parks-Cramer Co., Fitchburg, Mass.

EXPERIMENTER. "What's New in Radio" is the subject discussed in the July, 1931 issue of this publication. The General Radio Company, Cambridge A, Mass.

GAS SERVICE JOURNAL. A few of the articles in the July, 1931 issue of this publication are: "City of Chanute, Kansas, Tax Free Through Municipal Ownership;" "The Ignition Velocity of Gas Mixtures;" and "Gas Also Used For Cooking on Dirrigible Los Angeles." Pittsburgh Equitable Meter Co., 400 Lexington Avenue, Pittsburgh, Pa.

WATER WORKS JOURNAL. "The Pittsburgh Water Works and Pressure Zoning" by James H. Kennon, is one of the leading articles in the July, 1931 issue of this journal. Pittsburgh Equitable Meter Co., 400 Lexington Avenue, Pittsburgh, Pa.

SWITCHGEAR. Circular 1915 lists the installations of metal enclosed switchgear, includes photographs of some of these, and describes various types of this equipment. Circular 1899 describes metal enclosed switchgear in detail. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

OIL TESTING APPARATUS. List No. 96 is devoted to apparatus for testing petroleum, tar, asphalt and their products. A. Gallenkamp & Co., Ltd., 17 Sun Street, Finsbury Sq., London E.C.2, England.

SPECIALTIES FOR POWER PLANTS. Catalogue No. 400 describing and illustrating power plant instruments and other specialties. J. E. Lonergan Company, 211 Race St., Philadelphia, Pa.

THERMOMETERS. Circular 255-P describes resistance thermometer installation for every refrigerating temperature problem. The Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

CONTROLLERS. A circular describing and illustrating the potentiometer anticipatory controller. Leeds & Northrup Co., 4901 Stenton Avenue, Philadelphia, Pa.

TENSION INDICATOR. A circular describing an instrument for determining the load on a wire rope. Martin-Decker Corp. 3431 Cherry Ave., Long Beach, Calif.

MICROSCOPES. Illustrated Price List No. 29 covers microscopes, microscopical accessories and Polarizing Apparatus. J. Rosenbaum, Berlin S. O. 16, Michaelkirchstrasse 17, Germany.

ARC LAMP-BOLOMETER-SPECTROGRAPH. Three leaflets describing an x-ray bolometer, a vacuum iron arc lamp and a spectrograph of great intensity. P. J. Kipp & Zonen, Delft Holland.

POTENTIOMETER PYROMETER. A circular introducing the "Micromax" an improved potentiometer pyrometer. Leeds & Northrup Co. 4901 Stenton Ave., Philadelphia, Pa.

STEAM TRAP. Bulletin No. 1015 describing and illustrating a thermostatic steam trap with unique differential setting feature and reversible and renewable double life seat and disc. C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y.

OPTICAL INSTRUMENTS. Bulletin No. 126 contains information on Comparators, Rapid Setting Wavelength Spectrometer, Ultra Violet Monchromator, and Polarizing Spectrophotometer. The Gaertner Scientific Corporation, 1201 Wrightwood Avenue, Chicago, Ill.

X-RAY STEREOSCOPE. A booklet describing a new X-ray stereoscope having improvements which make possible a more extended use of this very valuable technique. Bausch & Lomb Optical Co., Rochester, N. Y.

METALLIC AND NON-METALLIC GASKETS. Catalogue H is the identification of a 94-page general catalogue on gaskets, gasket materials, and packings used in the various industries. Victor Manufacturing & Gasket Co., 5750 Roosevelt Road, Chicago, Ill.

CAPACITORS. 20-page Catalogue No. GEA-77D describes capacitors for power-factor correction. General Electric Company, Schenectady, N. Y.

TYCOS. The July, 1931 issue of Tycos Rochester contains the following articles: "Trying to Do Something About the Weather;" "Temperature Control Gives Us Our Citrus Fruits;" "Rubber From Weeds;" etc. Taylor Instrument Companies, Rochester, N. Y.

ADIABATIC CALORIMETRY. Bulletin E 14 entitled, "Why Adiabatic Calorimetry?" This describes the principles of heat transfer in the adiabatic calorimeter. Burgess-Parr Company, 111 West Monroe Street, Chicago, Ill.

DIRECTIONAL GYRO. A circular describing a directional gyro which is an airplane navigating instrument for indicating to the pilot the compass course of his plane. Sperry Gyroscope Company, Inc., Manhattan Bridge Plaza, Brooklyn, N. Y.

THE GRAPHIC. "Graphic Instruments in a Modern Steel Plant" is the title of the article in No. 631 of this publication. The Esterline-Angus Company, Indianapolis, Ind.

WIRE GAUGE. A leaflet illustrating Model 493 Wire Gage. Federal Products Corp., Provdence, R. I.

POTENTIOMETER PYROMETER. An attractive 12-page folder showing in tabloid form the principal features of the potentiometer pyrometer. This folder shows many of the constructional features substantiating the claims for extreme accuracy and ruggedness of this new instrument. The Brown Instrument Company, Wayne and Roberts Aves., Philadelphia, Pa.

MICROSCOPES. A booklet describing microscopes as to their importance in the medical profession. B. K. Elliott, 126 Sixth Street, Pittsburgh, Pa.

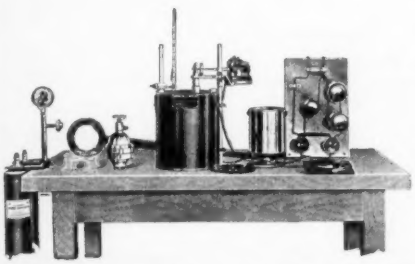
SCIENTIFIC INSTRUMENTS. 112-page General Catalogue H describes thermometers, hydrometers, barometers, psychrometers, hygrometers, thermoregulators and instruments generally regarded as complementary thereto. Hiergesell Bros., 2518 N. Broad St., Philadelphia, Pa.

ELECTRIC MELTING POTS. Bulletin TC-11 describes electric melting pots and other electrically heated industrial equipment. Harold E. Trent Co., 618 N. 54th St., Philadelphia, Pa.

THERMOSTATS. A circular describing an indicating thermostat for greenhouses. Standard Thermometer, Inc. 65 Shirley St., Boston, 19, Mass.

STRAIN GAGES. A booklet describing and illustrating optical strain gages for the precise measurement of tension and compression strains in hot and cold metal specimens, brick, concrete and similar materials and for the testing of riveted joints and other structural members. American Instrument Co. Inc. 774 Girard St. N. W Washington, D. C.

THE NEW
EMERSON FUEL CALORIMETER
WITH
STAINLESS STEEL BOMB



The Greatest Value in Calorimeters ever placed on the market.

The Special Stainless Steel Bomb is Absolutely Acid Proof.

Write to

EMERSON APPARATUS COMPANY
176 TREMONT STREET MELROSE, MASS.

Rawson Ultra Sensitive Semi-Suspended Meters
TYPE 5073

Suitable for experimental work with Photo Electric Cells, Grid Currents on Tubes, Leakage Resistance over Insulation, etc.

SIZE 5"x4⅛"x 2⅝" DEEP
OVERALL HEIGHT 5⅞"

Currents as low as .003 microampere can be measured. Suitable multipliers can be added to extend the range to any desired value, controlled by a well designed selector switch.

These meters can also be supplied in Type 503 and Type 505.

Write for information.

RAWSON ELECTRICAL INSTRUMENT CO.
Incorporated 1918
CAMBRIDGE, MASS.

Branch Office: 91 Seventh Ave. New York City

Mid-Western Representative: Earl N. Webber Daily News Bldg., Chicago, Ill.

Also manufacturers of AC or DC Thermal Multimeters, Microammeters, Milliammeters and Ammeters, Microvolt, Millivolt and Voltmeters, Cable Testers, Timers, Earth Current Meters, Fluxmeters, Thermocouples, Electrostatic Voltmeters, Wattmeters, etc. ***Write for Bulletins.***

BUYERS' GUIDE

to instruments and devices for measurement, inspection or control

If you are unable to find what you require in the Buying Section of INSTRUMENTS—write Information Section, Instruments Publishing Co., Pittsburgh, Pa. Give complete information of requirements.

ABRASION TESTERS
Atlas Electric Devices Co.

ACCELERATED TESTING CABINETS
Atlas Electric Devices Co.

ACIDITY RECORDERS
Leeds & Northrup Co.

ACOUSTIMETERS
Burgess-Parr Co.

AIR FLOW INDICATOR
Brown Instrument Co.
Foxboro Co.

AIR METERS
Foxboro Company
Taylor Instrument Cos.

ALIDADES

ALTIMETERS
Tagliabue Mfg. Co., C. J.

AMMETERS—Indicating
General Radio Co.
Jewell Electrical Instrument Co.
Rawson Elect. Inst. Co.
Weston Electrical Inst. Corp.

Recording
Bristol Company
Tagliabue Mfg. Co., C. J.

ANEMOMETERS
Bristol Co.
Taylor Instrument Companies

ARMATURE TESTING EQUIPMENTS
Westinghouse Elec. & Mfg. Co.

ASPHALT TESTING APPARATUS
Tagliabue Mfg. Co., C. J.

ATTENUATION NETWORKS
General Radio Company
Rubicon Company

AUDIO-FREQUENCY OSCILLATORS
General Radio Company

BALANCES
Alfred Suter

BAROMETERS—Aneroid, Mercurial, Recording
Bristol Company
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

BATTERY TESTERS
Weston Electrical Inst. Corp.

BEARING TESTERS
Burgess-Parr Co.

BOARDS, INSTRUMENTS
Foxboro Co.

BRAKE TESTING METER

BRIGES, ELECTRICAL
Capacities, Conductivity, Hoopes, Inductance, Kelvin, Resistance, Temperature, Wheatstone
General Radio Co.
Leeds & Northrup Co.
Rubicon Company

CABLE TESTERS
Leeds & Northrup Co
Rawson Elec. Inst. Co
Rubicon Company

CALORIMETERS
Peroxide, Oxygen Bomb
Burgess-Parr Co.
Emerson Apparatus Co.
Gaertner Scientific Co.

CAPACITANCE METERS
General Radio Co.
Leeds & Northrup Co.
Rubicon Company
Weston Elec. Inst. Corp.

CARBON DIOXIDE METERS
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.

CARBON MONOXIDE METERS
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.

CATHETOMETERS
R. Y. Ferner Co.
Gaertner Scientific Corp.

CEMENT TESTING INSTRUMENTS
Alfred Suter

CHRONOGRAPHS
R. Y. Ferner Co.
Gaertner Scientific Corp.
Leeds & Northrup Co.

CHRONOMETERS
R. Y. Ferner Co.
Tagliabue Mfg. Co., C. J.

CLOCKS—Gage Board
Brown Instrument Co.
Bristol Company
Foxboro Co.

CLOUD & POUR TEST APPARATUS
Tagliabue Mfg. Co., C. J.

COILS
Resistance, Inductance, Special.
General Radio Co.
Leeds & Northrup Co.
Rubicon Company

COIL TESTING EQUIPMENTS
Leeds & Northrup Co.
Rubicon Company

COLOR TESTER
Atlas Electric Devices Co.

COLORIMETERS
Atlas Electric Devices Co.
Tagliabue Mfg. Co., C. J.

COMBUSTION CONTROL EQUIPMENT
Brown Instrument Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.

COMMUNICATION MEASURING INSTRUMENTS
General Radio Company

COMPASS
Taylor Instrument Companies

COMPARATORS
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.
Gaertner Scientific Corp.

CONDENSER LEAKAGE RECORDERS
Leeds & Northrup Co.

CONDENSERS—Electrical
General Radio Co.
Leeds & Northrup Co.
Rubicon Company

CONDUCTIVITY METERS
Indicating, Recording, Controlling
Leeds & Northrup Co.
Rubicon Company

CONCENTRATION RECORDERS
Leed & Northrup Co.

CONSTANT SPEED & FREQUENCY SETS
Leeds & Northrup Co.

CONTOUR MEASURING PROJECTOR
Bausch & Lomb Optical Co.

CONTROLS, AUTOMATIC

Condensation
Tagliabue Mfg. Co., C. J.

Damper
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Minneapolis Honeywell Co
Tagliabue Mfg. Co., C. J.

Demand Pressure
Foxboro Company

Feed Water
Brown Instrument Co.
Foxboro Co.

Filter Rate
Brown Instrument Co.
Foxboro Co.

Flow
Brown Instrument Co
Foxboro Co.

Gravity
Tagliabue Mfg. Co., C. J.

Humidity
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Humidity & Temperature
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Minneapolis Honeywell Co
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Liquid Level
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Tagliabue Mfg. Co., C. J.

FEDERAL

DIAL INDICATORS

Comparators
Amplifying Gauges
Thickness Gauges
Depth Gauges
Thread Lead Gauges
Pitch Diameter Gauges
Cylinder Gauges
Paper Gauges
Fabric Gauges
Rubber Gauges
Tap Comparator Gauges
Gear Tooth Comparators
Cutter Testing Gauges
Internal and External Grinding Gauges
Caliper Gauges

Federal Products Corporation
Providence, R. I.

CHICAGO CLEVELAND DETROIT MUNCIE NEW YORK

DE KHOTINSKY LABORATORY CEMENT

This Cement was originally prepared by Captain A. DeKhotinsky in 1882 for making air-tight joints in incandescent lamp bulbs and vacuum tubes, and up to the present time nothing better has been produced. It is useful as an insulating material and protection against corrosion, and will be found indispensable in the laboratory.

The Cement is obtainable in three different grades of hardness and in one or two ounce sticks.
Price per ounce . . . . . $.75

THE GAERTNER SCIENTIFIC CORPORATION
1201 Wrightwood Avenue Chicago, U. S. A.

Type V-30 Gas Valves for low pressure gas

Pressure Controller (Pressuretrol)

Automatic Control

increases your uniformity

Uniformly high quality, less product spoilage, reduced supervision and fuel costs result from investing in Minneapolis-Honeywell automatic controls for your vats, ovens, kilns and furnaces.

Motorized valves for regulating gas, oil, water or steam flow; relays; temperature and pressure controllers; combustion safety controllers. For complete information write

MINNEAPOLIS-HONEYWELL REGULATOR CO.
2735 Fourth Avenue South Minneapolis, Minnesota

YOU SHOULD HAVE

An Accurate Standard of Length
with which to check
Your Measuring Apparatus

Precision scales of any length and with any graduation are made by the Société Genevoise d'Instruments de Physique

THE R. Y. FERNER CO.
INVESTMENT BLDG. WASHINGTON, D. C.

Pressure & Vacuum
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Pyrometer
Bristol Company
Brown Instrument Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Rate-Volume
Foxboro Co.

Refrigeration
Bristol Co.
Brown Instrument Co.
Leeds & Northrup Co.
Taylor Instrument Cos.

Special
Leeds & Northrup Co.
Minneapolis-Honeywell Co.
Rubicon Company

Tachometer
Brown Instrument Co.
Foxboro Co.
Weston Elec. Inst. Corp.

Temperature-Time
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

Thermometer
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Thermostat
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Taylor Instrument Companies

Thickness

Time
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

Unit Heater
Minneapolis-Honeywell Co.

Vacuum
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

Valve—Motor Operated
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Water Level
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

CONVERTERS
Bodine Electric Co.

COORINATOGRAPHS

COUNTERS—Revolution
Amthor Testing Inst. Co.
Bristol Company
Brown Instrument Co
Southwark Fdry. & Mach Co

Stroke
Bristol Company
Southwark Fdry. & Mach. Co.

COUPLING TRANSFORMERS
General Radio Company

CURRENT RECORDERS
Bristol Company
Leeds & Northrup Co.

CURRENT REGULATORS

CYCLE COUNTERS
General Radio Co.

CYLINDERS-GRADUATED
Tagliabue Mfg. Co., C. J.

DECELEROMETER

DEFORMETER (Beggs)
Southwark Fdy. & Mach. Co.

DEMAND METERS

Gas
Foxboro Company

Electric

DENSITOMETERS

DENSOMETERS

DIVIDING HEAD

Optical
Bausch & Lomb Optical Co.

DIVIDING MACHINES
R. Y. Ferner Co.
Gaertner Scientific Corp.

DRAFT GAGES—see Gages

DYNAMIC BALANCING EQUIPMENT
Alfred Suter

DYNAMOTORS
Bodine Electric Co.

EARTH CURRENT METERS
Rawson Elec. Inst. Co.

ELECTRIC TELEMETER
Southwark Fdry. & Mach. Co.

ELECTRIC WAVE FILTER SECTIONS
General Radio Company

ELECTROMETERS
Rubicon Co.

EMPLOYEES' "IN AND OUT" TIME RECORDERS

ENGINE INDICATORS
Southwark Fdry. & Mach. Co.

EXTENSOMETER
Southwark Fdry. & Mach. Co.
Alfred Suter

FADE-OMETER
Atlas Electric Devices Co.

FATIGUE TESTERS
Atlas Electric Devices Co.
Southwark Fdry. & Mach. Co.
Alfred Suter

FAULT FINDERS
General Radio Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

FLASH & BURNING POINT TESTERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

FLOW METERS
Brown Instrument Co.
Foxboro Co.

FLUXMETERS
Leeds & Northrup Co.
Rawson Electrical Instr. Co

FOLDING TESTER

FRACTIONAL HORSEPOWER MOTORS
Bodine Electric Co.

FREEZING CABINET
Atlas Electric Devices Co.

FREQUENCY METERS

Indicating
Jewell Electric Instrument Co
Leeds & Northrup Co.
Weston Elec. Inst. Corp.

Controlling
Leeds & Northrup Co.

Recording
Bristol Company
Leeds & Northrup Co.

Standards
General Radio Co.

FUEL ANALYSIS APPARATUS
Burgess-Parr Co.

FUEL FLOW INDICATOR

FURNACE CONTROLS
Leeds & Northrup Co.
Taylor Instrument Cos.

FUSES
Instrument

GAGE RODS
Tagliabue Mfg. Co., C. J.

GAGE TESTING OUTFITS
Amthor Testing Inst. Co.

GAGES

Absolute Pressure
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Amplifying
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.

Comparator
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.

Cylinder
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.

Deformation
Southwark Fdry. & Mach. Co.

Depth
B. C. Ames Co.
Brown Instrument Co.
Federal Products Co.
Foxboro Company

Dial
B. C. Ames Co.
Federal Products Corp.
R. Y. Ferner Co.

Differential Pressure
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

Draft
Amthor Testing Inst. Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Drill
Bausch & Lomb Optical Co.

Grinding
Federal Products Corp.

Liquid Level
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Loss of Head
Bristol Co.
Brown Instrument Co.
Foxboro Co.

Pitch Diameter
Federal Products Corp.
R. Y. Ferner Co.

Pocket
Amthor Testing Inst. Co.
Federal Products Corp.

Pressure
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Alfred Suter
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Pressure-Temperature
Bristol Company
Brown Instrument Co.
Foxboro Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

Pressure & Vacuum
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Profile
Bausch & Lomb Optical Co

Rain
Taylor Instrument Companies

Recording—Distance
Bristol Company
Brown Instrument Co.
Taylor Instrument Cos.

Strain
Southwark Fdry. & Mach. Co.
Alfred Suter

Tester
Southwark Fdry. & Mach. Co.

Thickness
B. C. Ames Co.
Amthor Testing Inst. Co.
Federal Products Corp.
R. Y. Ferner Co.

Volume
Brown Instrument Co.
Foxboro Co.

Water Level for Boilers
Bristol Company
Brown Instrument Co.
Foxboro Co.

Wind
Bristol Co.
Brown Instrument Co.
Taylor Instrument Companies

GALVANOMETERS
Brown Instrument Co.
General Radio Co.
Illinois Testing Labs., Inc.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Electrical Inst. Corp.

GAS ANALYTICAL METERS

Chemical
Tagliabue Mfg. Co., C. J.

Electrical
Brown Instrument Co.
Leeds & Northrup Co.

GAS LEAK INDICATORS
Taylor Instrument Companies

GASOLINE METERS
Buffalo Meter Co.

GAS-METERS
Brown Instrument Co.
Foxboro Co.

GASOMETERS

GEOPHYSICAL INSTRUMENTS

GOVERNORS

Laboratory Dry & Wet Gas Pressure
Bristol Company
Brown Instrument Co.
Tagliabue Mfg. Co., C. J.

Pump
Tagliabue Mfg. Co., C. J.

GLASS STRAIN TESTERS

GREASE TESTING APPARATUS
Tagliabue Mfg. Co., C. J.

GROUND DETECTORS
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

GROUND-OHMER
Leeds & Northrup Co.

GYPSUM TESTING INSTRUMENTS
Alfred Suter

HARDNESS TESTERS
Southwark Fdry. & Mach. Co.
Alfred Suter

HARMONIC ANALYZERS
Leeds & Northrup Co.

HELIOSTATS
Gaertner Scientific Corp.

HIGH FREQUENCY APPARATUS
Rubicon Company
Weston Elec. Inst. Corp.

HIGH VOLTAGE

Fuses

Indicators
Weston Elec. Inst. Corp.

Measuring Devices
Weston Elec. Inst. Corp.

Testing Devices

HUMIDITY CONTROLLERS
Bristol Company
Foxboro Co.
Taylor Instrument Cos.

HUMIDITY RECORDERS

Wet & Dry Bulb Thermometers
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

HYDROGEN ION METERS

Indicating
Leeds & Northrup Co.
Rubicon Company

Controlling, Recording
Leeds & Northrup Co.

HYDROMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

HYGROMETERS
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

IMPACT HARDNESS TESTER
Alfred Suter

IMPACT TESTING MACHINES
Alfred Suter

Alternating

INDICATORS—See Gages

INDUCTANCES
General Radio Co.
Leeds & Northrup Co.
Rubicon Company

INSTRUMENT CALIBRATION AND REPAIRS
Amthor Testing Inst. Co.
Jewell Electrical Instrument Co.
Rubicon Company
Weston Elec. Inst. Corp.

INSTRUMENT FUSES

INSTRUMENT OILS

INSTRUMENT TRANSFORMERS
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

INSULATION TESTING EQUIPMENT
Leeds & Northrup Co.
Rubicon Company

INTEGRAPHS & INTEGRATORS
Leeds & Northrup Co.

INTERFEROMETERS
Gaertner Scientific Corp.

INVERTED CONVERTERS
Bodine Electric Co.

JOB TIMING RECORDERS

KEYS AND SWITCHES
General Radio Co.
Leeds & Northrup Co.
Rubicon Company

KILNBOY
Foxboro Co.

KILOVOLT AMPERE METERS

KLYDONOGRAPHS

LABORATORY WASHING MACHINES
Atlas Electric Devices Co.

LACTOMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

LAUNDER-OMETER
Atlas Electric Devices Co.

LENGTH MEASURING MACHINES
R. Y. Ferner Co.
Gaertner Scientific Corp.

LEVELS

Centering
Bausch & Lomb Optical Co.
R. Y. Ferner Co.

Engineer's, Wye, Precision, Prism
R. Y. Ferner Co.
Taylor Instrument Companies

LIQUID METERS
Buffalo Meter Co.

LOCOMOTIVE INDICATORS
Southwark Fdry. & Mach. Co.

LUSTER METERS

MACHINE OILS

MAGNETOMETERS
Rubicon Company

MANOMETERS
Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
Alfred Suter

MASTER CLOCKS
Gaertner Scientific Corp.

MEGOHMMETERS
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Rubicon Company

MEGOHM VOLTMETERS
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

MELTINGPOINT APPARATUS
Burgess-Parr Co.
Tagliabue Mfg. Co., C. J.

METER PROVERS, Gas

METER TESTERS, Gas

MICROMETERS
Amthor Testing Inst. Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

MICROAMMETERS
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.

MICROFARADMETERS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

MICRO PYROMETERS

MICROSCOPES
Brinell
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Alfred Suter
Measuring
R. Y. Ferner Co.
Metallographic
Bausch & Lomb Optical Co.
Petrographical
Bausch & Lomb Optical Co.
Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

MICROTOMES
Bausch & Lomb Optical Co.

MILLIAMMETERS
General Radio Co.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.

MILLIVOLTMETERS
Bristol Company
Brown Instrument Co.
Illinois Testing Labs., Inc.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Taylor Instrument Companies
Weston Electrical Inst. Corp.

MOTOR RADIATOR VALVES
Minneapolis-Honeywell Co.

MOTION RECORDERS
Mechanical
Bristol Company
Foxboro Co.
Southwark Fdry. & Mach. Co

MOTORS
Bodine Electric Co.

MOTOR GENERATOR SETS
Bodine Electric Co.

MULTIMETERS
Rawson Electrical Instrument Co

MULTIPLIERS
Jewell Electrical Instrument Co
Leeds & Northrup Co.
Weston Electrical Inst. Corp.

NEON FILLED TUBES

NEPHELOMETERS

OHM METERS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Rubicon Company
Weston Electrical Inst. Corp.

OILS

OIL METERS
Buffalo Meter Co.

OIL TESTING APPARATUS
Atlas Electric Devices Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

OPERATION RECORDERS
Electrical
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.

ORIFICE METERS
Brown Instrument Co.
Foxboro Co.

ORSAT APPARATUS

OSCILLOGRAPHS
General Radio Co.

OVENS
Textile Conditioning
Emerson Apparatus Co.

OXYGEN RECORDERS
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.

PAINT TESTING INSTRUMENTS
Atlas Electric Devices Co.

PANTOGRAPHS
Gaertner Scientific Corp.

PAPER TESTING INSTRUMENTS
Atlas Electric Devices Co.

PERFORMANCE METER

PERMEAMETERS
Leeds & Northrup Co.
Rubicon Company

PAPERTESTINGINSTRUMENTS
Amthor Testing Inst. Co.

PERISCOPES
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

PHASE INDICATOR

PHASE SEQUENCE INDICATOR

PHONOGRAPH TURNTABLES, Electric
Bodine Electric Co.

PHOTOELECTRIC COLOR ANALYZERS

PHOTOELECTRIC COLOR COMPARATOR

PHOTO-ELECTRIC TUBES

PHOTOMETERS
Gaertner Scientific Corp.
Bausch & Lomb Optical Co.
Leeds & Northrup Co.

PHYSICAL TESTING MACHINES
Amthor Testing Inst. Co.
Atlas Electric Devices Co.
Southwark Fdry. & Mach. Co.
A. Suter

PITOT TUBE METER
Brown Instrument Co.
Foxboro Co.

PLANIMETERS
Automatic Flow Record
Brown Instrument Co.
Foxboro Company
Linear
Brown Instrument Co.
Southwark Fdry. & Mach. Co.
Radial
Bristol Company
Foxboro Co.
Square Root
Foxboro Co.

POLARISCOPES
Gaertner Scientific Corp.

POSITION RECORDERS
Bristol Company
Foxboro Co

POTENTIAL DETECTORS
Leeds & Northrup Co.

POTENTIOMETERS—Indicating
Brown Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Recording & Controlling
Leeds & Northrup Co.

POWER FACTOR METERS
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

POWER FACTOR REGULATORS

PRESSURE RECORDERS
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

PROCESS TIMING AND SIGNALING INSTRUMENTS
Bristol Company

PROGRAM INSTRUMENTS
Leeds & Northrup Co.

PROJECTION LANTERNS
Bausch & Lomb Optical Co.

PROTRACTOR
Optical
Bausch & Lomb Optical Co.

PSYCHROMETER
Recording
Bristol Company
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Sling
Taylor Instrument Companies

PYROMETERS
Optical
Leeds & Northrup Co.
Radiation
Indicating
Brown Instrument Co.
Leeds & Northrup Co.
Taylor Instrument Companies
Recording
Brown Instrument Co.
Leeds & Northrup Co.
Taylor Instrument Companies
Thermo-electric
Immersion
Bristol Company
Brown Instrument Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Taylor Instrument Companies
Indicating
Bristol Company
Brown Instrument Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Taylor Instrument Companies
Recording and Controlling
Bristol Company
Brown Instrument Co.
Leeds & Northrup Co.
Taylor Instrument Companies
Surface Contact
Bristol Company
Brown Instrument Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Taylor Instrument Companies

RADIO FREQUENCY OSCILLATORS
General Radio Company
Jewell Electrical Inst. Co.

RADIO SET ANALYZERS
General Radio Company
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

RADIO TUBE CHECKERS
General Radio Company
Jewell Electrical Instrument Co
Weston Electrical Inst. Corp.

RADIO TEST PANEL
Jewell Electrical Instrument Co.
Rubicon Company
Weston Electrical Inst. Corp.

REFRACTOMETERS
Bausch & Lomb Optical Co.

REGULATORS—See Controls

RELAYS
General Radio Co.
Jewell Electrical Instrument Co.
Minneapolis-Honeywell Co.
Weston Electrical Inst. Corp.

REMOTE METERING EQUIPMENT
Bristol Company
Brown Instrument Co.
Leeds & Northrup Co.

RESISTANCE—Electrical
General Radio Co.
Leeds & Northrup Co.
Rubicon Company

RHEOSTATS
General Radio Co.
Rubicon Company

ROTOSCOPE

RUBBER AGING APPARATUS
Emerson Apparatus Co.

RUBBER TESTING INSTRUMENTS

SACCHARIMETERS
Bausch & Lomb Optical Co.
Taylor Instrument Companies

SACCHAROMETERS
Tagliabue Mfg. Co., C. J.

SALINITY INDICATORS
Leeds & Northrup Co.
Rubicon Company

SCALES
Amthor Testing Instrument Co.
Gaertner Scientific Corp.
Alfred Suter

SCRATCH HARDNESS TESTER

SEISMOGRAPHS
R. Y. Ferner Co.

SERVICE RECORDERS

SHUNT METERS
Bristol Co.

SHUNTS
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

SIGNALING DEVICES—Automatic
Brown Instrument Co.
Leeds & Northrup Co.
Rubicon Company

SLIDE RULES

SLOW SPEED MOTORS
Bodine Electric Co.

SMOKE INDICATORS & RECORDERS
Leeds & Northrup Co.

SOIL PRESSURE CELLS

SPECIAL INSTRUMENTS
Amthor Testing Inst. Co.
Burgess-Parr Co.

SPECIAL ELECTRICAL INSTRUMENTS
Atlas Electric Devices Co.
Bristol Co.
Brown Instrument Co.
General Radio Co.
Illinois Testing Labs., Inc.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Rubicon Company
Weston Electrical Inst. Corp.

SPECIAL RECORDING DEVICES

SPECIFIC GRAVITY APPARATUS—Gas

SPECTROGRAPHS
R. Y. Ferner Co.
Gaertner Scientific Corp.

SPECTROSCOPES
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

SPECTROPHOTOMETERS
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

SPEED INDICATORS
See Tachometers

SPEED RECORDERS
Amthor Testing Inst. Co.
Brown Instrument Co.
Leeds & Northrup Co.

STANDARD CELLS
Weston Electrical Inst. Corp.

STEEL TAPES

STOP WATCHES
R. Y. Ferner Co.

STRAIN GAGES
Southwark Fdry. & Mach. Co.
Alfred Suter

STRESS INDICATOR

STROBOSCOPES

SULPHUR DIOXIDE METERS
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.

SULPHUR DETERMINATION APPARATUS
Burgess-Parr Co.
Tagliabue Mfg. Co., C. J.

SUNSHINE RECORDERS
Leeds & Northrup Co.
Taylor Instrument Companies

SURGE RECORDERS

SYNCHRONIZING FORKS—Electrical
General Radio Co.
Leeds & Northrup Co.

SYNCHRONOUS MOTORS
Bodine Electric Co.

TACHOSCOPES
Amthor Testing Inst. Co.
Brown Instrument Co.

TACHOMETERS
Amthor Testing Instrument Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Weston Electrical Inst. Corp.

TELESCOPES
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

TENSILE TESTERS FOR PAPER WIRE, SHEETS, ETC.
Amthor Testing Instrument Co.
Alfred Suter

TENSOMETER (Huggenberger)
Southwark Fdry. & Mach. Co.

TESTERS, Gas

TESTING MACHINE

Portable—Tensile—Compression
Southwark Fdry. & Mach. Co.

Universal
Amthor Testing Inst. Co.
Southwark Fdry. & Mach. Co.
A. Suter

TEXTILE TESTING INSTRUMENTS
Atlas Electric Devices Co.
Emerson Apparatus Co.
A. Suter

THEODOLITES

THERMO-JUNCTIONS(Electric)
General Radio Co.
Rawson Electrical Instrument Co

THERMOMETERS

Gas Filled
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Mechanical
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

Mercurial
Bristol Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Resistance
Brown Instrument Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.

Vapor-Tension
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Wet & Dry Bulb
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

THERMOSTATS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

TIME OPERATION RECORDERS
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.

TIME RECORDERS
Bristol Company
Brown Instrument Co.
Gaertner Scientific Corp.
Foxboro Co.

TIME SWITCHES
Claud S. Gordon Co.

TIMERS
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Rubicon Company

TINTOMETER

TORSIOGRAPH
Southwark Fdry. & Mach. Co.

TORSION MACHINES
Alfred Suter

TRANSFORMATION POINT RECORDERS
Brown Instrument Co.
Leeds & Northrup Co.

TRANSFORMERS
General Radio Co.
Weston Electrical Inst. Co.

TRANSITS

Engineer's, Surveyors, Mine
Gaertner Scientific Corp.

Pocket
Taylor Instrument Companies

TUNING FORKS—Electrically Driven
General Radio Co.
Gaertner Scientific Corp.
Leeds & Northrup Co.
Rubicon Company

TURBIDIMETERS
Burgess-Parr Co.

U-TUBE MANOMETERS
Amthor Testing Inst. Co.

VACUUM RECORDERS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

VACUUM TUBE BRIDGES
General Radio Company

VALVES

Automatic Shut Off
Bristol Company
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

Balanced
Brown Instrument Co.
Foxboro Co.
Claud S. Gordon Co.

Diaphragm
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Electrically Operated
Bristol Company
Brown Instrument Co.
Minneapolis-Honeywell Co.

Reducing
Claud S. Gordon Co.
Tagliabue Mfg. Co., C. J.

Regulating
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Safety, Fuel Shut-off
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.

VENTURI METERS
Brown Instrument Co.
Foxboro Co.

VIBROGRAPH
Southwark Fdry. & Mach. Co.

VIBROSCOPE

VISCOSIMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

VISCOSITY TUBES

VOLTAGE DIVIDERS
General Radio Co.
Rubicon Company

VOLT-AMMETERS
Jewell Electricall nstrument Co.
Weston Electrical Inst. Corp.

VOLTMETERS

Indicating
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.

Recording
Bristol Company
Leeds & Northrup Co.

Thermionic, Oxide Rectifier
General Radio Co.

WATER METERS
Foxboro Co.

WATER METERS—Hot and Cold
Buffalo Meter Co.

WATER & SEDIMENT APPARATUS
Tagliabue Mfg. Co., C. J.

WATTHOUR METERS

WATTMETERS

Indicating
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.

Recording
Bristol Company

WAVEMETERS
General Radio Co.

WAX MELTING APPARATUS
Tagliabue Mfg. Co., C. J.

WEAR-OMETER
Atlas Electric Devices Co.

WEATHER-OMETER
Atlas Electric Devices Co.

Weather-Ometer

"Standardized Weathering"

makes unnecessary the slow, unreliable testing of materials and organic protective coatings by out-of-door means. A number of samples may be placed in Weather-Ometer at one time and the factors of Sun, Rain, Cold and Heat reproduced in accelerated form under perfect control as to order, duration and intensity. Then the samples may be studied, analyzed, and charted for progressive deteriotation and breakdown. There is a real need for this machine in almost evert important industry. Let us explain where—why and how. Ask for Bulletin I-10.

By the Makers of Fade-Ometer and Launder-Ometer.

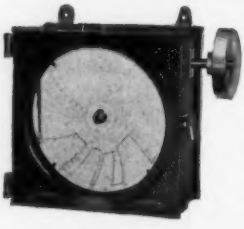
Distributors

New York Boston London Berlin

ATLAS ELECTRIC DEVICES CO.

361 West Superior Street Chicago, Illinois

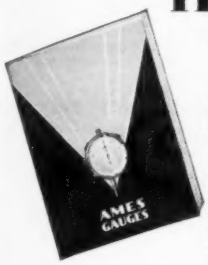
MEASURE EFFICIENCY



With an AMTHOR OPERATION RECORDER a complete detailed record is produced. Chart analysis shows Total Idle and Operating Time, Starting and Stopping Times, Production Speed at any time, all Slowdowns and Stops for any reason and the duration of each. It shows operating irregularities and every departure from schedule. Write for complete data.

AMTHOR TESTING INSTRUMENT CO., Inc.

315A Johnson St. Brooklyn, N. Y.



THE NEW 40-PAGE AMES DIAL GAUGE CATALOG!

Send today for the new Ames Gauge Catalog. Containing complete information about the construction, use and care of all types of Micrometer Dial Gauges, mountings, attachments, Upright Gauges, Pocket Gauges, Automotive Gauges, Lens Measures, Precision Verifiers, Comparators, Gauge Repair Service and Replacement Parts.

B. C. AMES CO. Waltham, Mass.

ADVERTISERS' INDEX

A

Ames Co., B. C. Waltham, Mass..... 17
Amthor Testing Instrument Co., 315-A Johnson St., Brooklyn, N. Y..... 16
Atlas Electric Devices Co., 361 West Superior St., Chicago, Ill..... 16

B

Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y..... 3
Bristol Company, Waterbury, Conn..... 1
Buffalo Meter Co., 2909 Main St., Buffalo, N. Y..... 17
Burgess-Parr Company, 111 West Monroe St., Chicago, Ill..... 6

E

Emerson Apparatus Co., 171 Tremont St., Melrose, Mass..... 9

F

Federal Products Corp., Providence, R. I. 11
Ferner Co., R. Y., Investment Bldg., Washington, D. C..... 11
Foxboro Co., Inc., Foxboro, Mass. Back Cover

G

Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill..... 11
General Radio Co., Cambridge A, Mass... 18

L

Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa..... 4

M

Minneapolis-Honeywell Regulator Co., 2735 Fourth Ave., So., Milwaukee, Wis. 11

R

Rawson Electrical Instrument Co., 90-92 Windsor St., Cambridge, Mass..... 9
Rubicon Company, 29 N. Sixth St., Philadelphia, Pa..... 18

T

Tagliabue Mfg. Co., C. J. Park & Nostrand Aves., Brooklyn N. Y.... Inside Front Cover
Taylor Instrument Cos., 95 Ames St., Rochester, N. Y..... Inside Back Cover

W

Weston Electrical Instrument Corp., 591 Frelinghuysen Ave., Newark, N. J..... 2

NIAGARA METERS
Niagara Meters measure any liquid not chemically destructive. Use them for accurate automatic measurement in place of gaugesticks, measuring tanks and other makeshift means. Eliminate exposure of liquids to contamination and fire hazard. Also for accurate keeping of cost and inventory records. Send for complete information.
BUFFALO METER CO.
2909 Main Street. Buffalo, N. Y.

When writing to the above companies, please mention INSTRUMENTS

INDEX CARD SECTION

A file card index will be a valuable asset. It is suggested that this index information be cut out, mounted on cards, and filed in your desk or in a file box on top of your desk. You will then have within easy reach an index of instrument information of incalculable value.

A Corrosion Tester for Pressure Vessels. CLOYD M. CHAPMAN. INSTRUMENTS Vol. 4, No. 10, October, 1931, pages 527-531, 13 figs.

The new corrosion tester is described and illustrated. A number of photographs illustrate the results obtained on different materials.

Elinvar for Instrument Hairsprings. GEORGE P. LUCKEY. INSTRUMENTS, Vol. 4, No. 10, October, 1931, page 532.

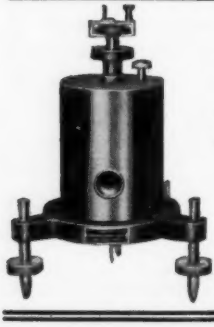
Briefly mentions the use of Elinvar for instrument hairsprings.

Measurement of Air Flow. E. OWER. INSTRUMENTS, Vol. 4, No. 10, October 1931, pages 533-540, 3 figs.

Chap. IX. This chapter is devoted to the various forms of manometers.

Speed and Acceleration Measurement. M. F. BÉHAR. INSTRUMENTS, Vol. 4, No. 10, October, 1931, pages 541-555, 29 figs.

Continuation of Chap. XV of Handbook of Industrial Instruments. This instalment covers:
Section 2. (Addendum) Tachometer Drives
12. U-tube Tachometers
18. Positive Pump Tachometers
19. Miscellaneous Tachometers—Inertia, etc.
20. Frequency Meters
21. Vibration Tachoscopes
24. Measurement of Differential Speed



Compton Electrometer

A sensitive modification of the original quadrant electrometer with adjustable electrostatic control.

Ask for Bulletin No. 330

RUBICON COMPANY

Electrical Instrument Makers

29 NORTH 6th STREET PHILADELPHIA, PA.

Electrical Measuring Instruments

for use at communication frequencies (0 to several million cycles per second)

Frequency Standards • Tube and Tuning Fork Oscillators • Resistance Boxes Bridges • Calibrated Inductors • Variable Air Condensers • Voltage Dividers Attenuation Networks • String Oscillograph • Thermionic and Oxide-Rectifier Voltmeters • Accessories: Rheostats, Transformers, Relays, etc.

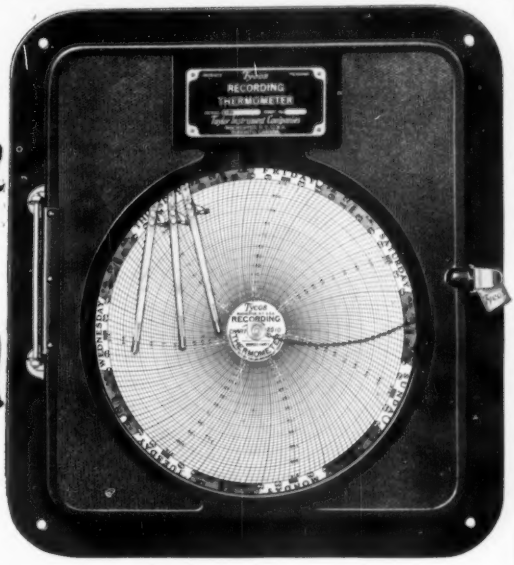
GENERAL RADIO COMPANY

Manufacturers of Electrical Measuring Apparatus for Laboratory and Industrial Use

CAMBRIDGE A, MASSACHUSETTS

When writing to the above companies, please mention INSTRUMENTS

Trim in Appearance Easily Installed



Tycos Flush Mounted Instruments

THESE Tycos Flush-Mounted Instruments are designed for panel-board installations and can be supplied as Recording Thermometers, Recording Pressure Gauges, Recording Temperature Regulators, or Recording Pressure Regulators.

They are available as recording instruments with one, two or three pens and as regulators to control one or two temperatures or pressures or one temperature and one pressure.

All the finest features of Tycos Recording Thermometers and Regulators are embodied in the Flush-Mounted Instruments.

Taylor Instrument Companies

ROCHESTER, N. Y., U. S. A.

In Canada
Taylor Instrument Company of Canada, Ltd.
Tycos Building, Toronto

In Great Britain
Manufacturing Distributors
Short & Mason, Ltd.
London, E-17

Tycos Temperature Instruments

INDICATING · RECORDING · CONTROLLING

FOXBORO
REG. U. S. PAT. OFF.
THE COMPASS OF INDUSTRY

Cut Your Own Cams!

WITH the new Foxboro Non-Recording Time Controller you can accurately maintain a predetermined cycle of operation in any process involving temperature or pressure. It is similar in construction to the standard Foxboro Recorder-Controller.

The principal feature of this new instrument is that it is equipped with a calibrated aluminum disc instead of a paper chart and a cam follower instead of a pen arm.

The calibrated cam disc is made by a special process that ensures accuracy, and can be cut to any schedule.

Where a wide variety of schedules are desired you can stock the calibrated discs and *cut your own cams* almost as easily as you can cut a paper chart.

Flexibility of Range—Economy of Operation—Accuracy and Dependability—these are the great distinctions of this Controller.

The Non-Recording Time Controller is designed for use on industrial processes where the relation of time to temperature and pressure is of importance. It is one hundred per cent automatic.

Write to Dept. AE for further particulars.

Non-Recording Time Controller

THE FOXBORO COMPANY - FOXBORO, MASS

New York Chicago Boston Philadelphia Detroit Pittsburgh
Cleveland Rochester, N. Y. Tulsa Atlanta Los Angeles
Dallas Portland, Ore. San Francisco Salt Lake City